A MODEL OF THE DIFFUSION OF MANAGEMENT SCIENCE IN SOUTH AFRICAN BUSINESS

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This thesis represents a culmination of a long interest in the development of Management Science in South African business. The interest in turn stems from practical experience of the difficulties involved in introducing basic concepts of Systems Development and Operations Research in local organizations. The work of the "Co-operative International Programme of Studies on Operations Research and the Management Sciences" was finally responsible for the decision to embark on the research described in the pages that follow. It is with gratitude that I acknowledge the assistance and interest displayed by Professor Meyer Feldberg of the Graduate School of Business, University of Cape Town who introduced me to the Co-operative Programme and subsequently supervised and motivated me whilst I was engaged in my research.

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The fieldwork, which was used to test the model of OR/MS Diffusion, took over two years to complete in ten South African

companies. During this period the executives of the companies concerned gave freely of their time and provided me with information and useful comment. Although they must remain anonymous I thank them most sincerely for their patience and understanding.

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ABSTRACT

A MODEL OF THE DIFFUSION OF MANAGEMENT SCIENCE ACTIVITIES IN SOUTH AFRICAN BUSINESS

This thesis presents a model of the process of diffusion of Management Science activity in South African business. A preliminary model is derived from available literature describing Management Science diffusion in the United States and Europe. This model is tested against data obtained in ten field studies performed in South African companies.

The model may be used to forecast the outcome of the diffusion of Management Science activities in local organizations. It is also possible to use the model to predict the future of Management Science in South Africa.

Management Science techniques are being employed by organizations in most industrialized countries throughout the world. In South Africa however, it has not been easy to introduce these techniques and it has often been extremely difficult to achieve successful implementation of Management Science recommendations. As a result there appears to be a need for a better understanding of the factors which influence the introduction and implementation of Management Science. This knowledge will help South African businessmen understand the pitfalls and problems associated with Management Science and enable them to at least ensure that a favourable climate is created for the establishment of the activity. It may also help Management Scientists understand why worthwhile projects sometimes fail and enable them to increase the chances of success.

Diffusion is the process by which an innovation spreads from its source of invention or creation to its adopters. The innovation need not be new in time, it merely has to be a new idea as perceived by individuals encountering it. The diffusion process describes the manner in which a new idea is communicated by one person to another, or by one group to another group. There are four fundamental elements which characterise the diffusion of an innovation:

1. the innovation itself

2. the method of communication

3. the social system in which the communication takes place

4. the time span of the diffusion process

A social system is a population which is functionally different and is engaged in a collective problem solving process. The time span of the diffusion process is dependent upon the reception of the innovation. The innovation may be immediately rejected or it may be favourably received and subsequently adopted. After adoption there may be a decision to discontinue the innovation i.e. to cease using it.

In the context of this thesis Management Science is the innovation, and the social system is the organization into which Management Science is introduced. The factors facilitating adoption or causing rejection are critical to this thesis and form the basis of the model. The process of communication of the innovation from individual (group) to individual (group) and the organizational relationships that exist between the individuals communicating knowledge of the innovation to the individuals receiving it are important aspects of the model.

For the purposes of this thesis a Management Science activity has been defined as one which "is performing work utilizing newer methods of mathematical analysis and/or which is involved in non-routine computer systems activities". It is important to make this definition as Management Science itself is identified under a variety of different organizational names such as operational research, operations evaluation, management science, systems analysis, systems research, etc.

On the basis of this definition recognisable Management Science activity has been in existence for over thirty years. It first emerged as a formal discipline in England at the beginning of World War II and was known as Operational Research or OR. The concepts of OR were established in the British and American armies during the war and subsequently spread to business and government in the two countries. Societies were formed to promote the new discipline and courses in OR were offered at undergraduate and graduate levels in most Universities and Business Schools.

As the accent of OR changed so did its name and by 1960 the discipline had become known as Management Science or Operations Research/Management Science - OR/MS. By 1970 OR/MS was an established and accepted activity in business and government in the United States, Britain and Europe. The diffusion process had reached the "adopted" stage of the cycle, although there had been many instances of rejection or discontinuation along the way. In the majority of industrialized nations OR/MS is no longer regarded as an innovation.

In South Africa the process of OR/MS diffusion has been significantly slower than it was in the US. It was not until 1967 that it became possible to study for a degree in OR/MS at a South African university and it was not until 1969 that the South African Operations Research Society was formed. There are less than 40 formally constituted OR/MS groups in South Africa and these tend to be located in local companies with international Head Offices or in large state controlled organizations. At this point in

time (1976) many South African managers still regard ORM/S as a recent innovation. Top Management attitudes towards OR/MS range from enthusiasm to scepticism and hostility, and the diffusion process is complex.

This thesis presents a model of the process of OR/MS diffusion in South African business. The model identifies those inhibiting and facilitating factors which control the diffusion process in individual organizations. Some of these factors appear to be peculiar to South Africa whilst others have been observed in international situations.

For the past ten years a Research Group at Northwestern University, Evanston, Illinois, has studied the diffusion of OR/MS and has concentrated on the identification of the factors which influence OR/MS success. The group has traced the history of OR/MS in over 100 companies in order to identify the factors which govern the rejection, discontinuation, and adoption of OR/MS in American organizations. Under the programme title of "The Co-operative International Programme of Studies of Operations Research and the Management Sciences" the group has published its findings extensively. The influence of factors such as leadership, sponsorship, top management support, and EDP backup on OR/MS success have been examined and documented. The group has produced what is known as the "Life Cycle" model of OR/MS diffusion.

Although the effort of the Northwestern programme has concentrated on the American environment, studies have also been carried out in a number of industrialized and developing countries that have participated in the Research project. This has provided further information with which to weight American findings to allow for the different states of economic and industrial development of the USA and other member nations.

Many of the factors identified by the Northwestern Group are included in the preliminary model of OR/MS diffusion in South Africa. In order to test the validity of the model a series of ten in-depth case studies of OR/MS diffusion were conducted in local companies. On the basis of this information it is possible to derive a refined model of the process of OR/MS diffusion in South African business.

The model combines aspects of the Life Cycle model of the Northwestern Group as well as the more widely known Authority-Innovation Decision diffusion model of Rogers and Shoemaker. It was necessary to expand the early stages of the Life Cycle model by including certain aspects of innovation diffusion in view of the difference in levels of technological development in America and South Africa.

It is hypothesised that the diffusion of OR/MS in South African business can be represented by two separate processes superimposed upon one another. The factors which influence the Primary Process in the "Two Process" model are different to those which influence the Secondary Process.

The Primary Process corresponds to the "Prebirth" Phase of the Life Cycle Model and the "Awareness, Interest, Evaluation" Phase of the Authority-Innovation Decision Model. During the Primary Process the Top Management of an organization becomes Aware of OR/MS and makes the decision to run a Trial of the activity or to reject OR/MS entirely. If OR/MS is rejected the Primary Process is complete and will not be followed by the Secondary Process. If Top Management decides to run a Trial the Primary Process is complete and is followed by the Secondary Process. The Primary Process is not complete until Top Management makes a conscious decision to reject OR/MS or to commit itself to a Trial.

In an environment of high technology where Management is regularly exposed to Innovation the significance of the Primary Process is not as great as that of the Secondary Process. This is particularly true of the United States and this is one of the reasons why American Research has concentrated on the factors influencing OR/MS success rather than the factors which influence the initial attitudes of Top Management to OR/MS.

The Primary Process of OR/MS diffusion is dependent upon the reaction of Top Management towards innovations such as OR/MS. If Top Management is disinterested in or sceptical of innovation it is unlikely that a formal Trial of OR/MS will be ordered. Although the Trial itself is part of the Secondary Process, the extent to which Top Management becomes involved in organising the Trial is partially a function of the attitude of Top Management towards OR/MS.

It is hypothesised that the outcome of the Primary Diffusion Process will be influenced by the Receptivity of Top Management for OR/MS. Receptivity is a composite term which incorporates the stages of Top Management Awareness, Interest and Evaluation in the Authority-Innovation Decision process. OR/MS is likely to be rejected during the Primary Process if the Receptivity of Top Management is low.

In South Africa Receptivity is positively associated with four factors. If one or more of these factors is present, then Top Management will be increasingly Receptive towards OR/MS. Conversely if all four factors are absent then Top Management will be indifferent or hostile towards OR/MS.

The factors which have been found to control Receptivity in the Primary Process are:

- the level of influence exerted by an International parent company or associate
- the level of professional training amongst Top Management
- the availability of EDP expertise with OR/MS experience

the level of Top Management exposure to Innovation as a result of overseas visits, seminars, etc.

The most important controlling factor is the influence of International Corporations on their South African subsidiaries or associates. Companies which are controlled by International parents or which have easy access to overseas expertise are likely to possess a Top Management Team that is more Receptive to OR/MS than a local organization with no international ties. In this sort of company Top Management Receptivity is often a requirement of employment. Furthermore an OR/MS function may be written into the organization chart, or alternatively required operating information may only be obtainable if OR/MS techniques are applied.

In the absence of this factor the three other factors control Receptivity. A young Professionally trained management team with modern norms is more Receptive than a Traditional family controlled team. Top Managers who have easy access to DP personnel with OR/MS experience are more Receptive than their counterparts in companies without this facility. The upward diffusion of OR/MS expertise from DP personnel to Top Management will increase Receptivity. Exposure of Top Management to innovation brings with it an awareness of innovation and increased Receptivity.

Receptivity ratings of the members of Top Management in an organization are often similar. This confirms that executives who achieve Top Management levels are required to exhibit the same norms and values as their colleagues. If the Top Management Team is large there may be a divergence of attitudes towards OR/MS. In these cases the role played by the sponsor is of particular importance, the sponsor being the member of Top Management actually promoting OR/MS. If the sponsor is Receptive and has high status within the organization this may offset the Hostile attitude of other members of the Top Management Team. Conversely a sponsor with low status and inadequate understanding of OR/MS may be unsuccessful in promoting OR/MS if the remainder of the organization are Hostile or Indifferent.

The field studies showed that there was a definite association between Receptivity and these four factors. The Top Management teams of companies which lack the four Controlling factors are either Indifferent or Hostile to OR/MS. As a result the Primary Process drags on or alternatively the Trial Phase of the Secondary Process is never completed.

The Secondary Diffusion Process involves the Trial of OR/MS and the subsequent decision by Top Management to discontinue OR/MS or to introduce it permanently into the organization. If the Trial is unsuccessful, Top Management may discontinue further OR/MS activity and the Secondary Process will be complete. If the Trial is a success, Top Management may decide to formally introduce OR/MS into the organization structure. Management is then perceived to adopt OR/MS and subordinates are forced to adopt OR/MS themselves. Subsequent success by the OR/MS activity may result in genuine adoption by Top Management and subordinates.

Failure of OR/MS projects may be caused by subordinates who have in fact rejected OR/MS. Continued failure can force Top Management to discontinue OR/MS thereby completing the Secondary Process. Alternatively the Secondary Process is complete when OR/MS is genuinely adopted by both Top Management and subordinates throughout the organization.

The Secondary Process is based upon the Rogers and Shoemaker Model and corresponds to the Introductory to Maturity Phases of the Life Cycle Model. All events in the Secondary Process are related to OR/MS success and the field studies confirmed that the Secondary Process of OR/MS diffusion in South Africa is controlled by OR/MS success.

In turn, the field studies showed that OR/MS success in companies in the Republic is dependent upon four Controlling factors. These are:

- The level of Top Management Support
- The level of Sponsorship
- The level of Information Systems Development
- The accessibility of Computer assistance

There is a degree of similarity between the factors controlling success in the Secondary Process and the factors influencing Receptivity in the Primary Process. A low Receptivity rating in the Primary Process would make subsequent Top Management support and sponsorship most unlikely. However, even though Top Management may be Receptive towards OR/MS they may not supply the necessary support and the level of sponsorship may not be adequate to ensure success. Furthermore, although the organization may have DP personnel with OR/MS experience, it is the accessibility of the computer which is of critical importance. Unless the OR/MS group enjoys comparatively unrestricted access to a computer, it will be difficult to satisfactorily design, implement, and monitor OR/MS projects.

There are two other factors which appear to exert a significant influence and assist in the achievement of success. These factors are the status of the OR/MS group within the organization and its demonstrated ability to achieve success. Once an OR/MS activity has shown that it is capable of performing worthwhile work, its chances of subsequent success are greater because its status and reputation are enhanced. In turn the group will find subsequent success easier to achieve as a result of its greater status. It is therefore essential that early projects - particularly during the Trial phase - are relevant, clearly defined and fairly easy to complete.

In the South African environment the level of Systems Development has a significant effect on OR/MS success. This is of particular interest because the field studies showed clearly

that Systems Development was positively associated with Receptivity. Top Managers in South Africa may display the same attitude towards Systems Development as they do towards other innovations such as OR/MS. As a result a company which has a Top Management Team with a high Receptivity rating is more likely to become involved in formal Systems Development activity than a company in which Top Management is Hostile to Innovation.

The Receptivity of Top Management can therefore have an indirect influence during the Secondary Process as well as the Primary. Should an OR/MS activity be established in an organization which is characterised by Top Management indifference or hostility towards OR/MS, neither support nor sponsorship will be forthcoming from Top Management and furthermore Internal Systems Development will probably be poor. It is therefore unlikely that OR/MS projects will be successful and the probability of the subsequent discontinuation of OR/MS in this environment is high.

The Two Process Diffusion Model also shows that it is possible for OR/MS activities to fail in an environment in which Top Management are committed to and receptive towards innovation. It is at this stage that the implication of factors such as Top Management Support and Sponsorship, Systems Development and Computer Availability must be evaluated in greater detail as these may be deficient in some respect.

An examination of the South African business environment indicates increasing application of OR/MS techniques during the next ten years. It is hoped that the Two Process Model will provide local businessmen with a better understanding of the diffusion concepts which relate to the introduction and implementation of OR/MS. A knowledge of the factors which govern adoption can assist Top Management in their efforts to create an organizational background which favours OR/MS success.

Inevitably there will be companies in which Top Management is indifferent or hostile towards the introduction of OR/MS. It will be important for would-be sponsors and practitioners of OR/MS in these situations to be aware of the factors which act on Top Management Receptivity. In view of the influence of Receptivity in both the Primary and Secondary Process it is essential that great attention is paid to the selection and management of OR/MS projects. The chances of successful diffusion in this type of organization are often so slight that it may be advantageous to first attempt to increase Receptivity before introducing OR/MS.

Finally, it is essential that Top Management, sponsors, and practitioners understand the effect of Information Systems development on OR/MS diffusion. Organizations with poorly developed systems and little experience of computers are unlikely to achieve financial savings or success with OR/MS. The introduction of recognised and accepted OR/MS techniques into these organizations often only increases Top Management hostility as a result of failure and unnecessary expenditure. This type of organization must first set its Systems house in order before attempting to reap the benefits of OR/MS application.

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CHAPTER 1

THE DIFFUSION OF INNOVATION

During the last ten years an increasing amount of work has been done on the manner in which new ideas, or changes, are disseminated amongst members of a social system. Generally referred to as "Diffusion of Innovation", research has concentrated on identifying the factors that promote or inhibit change amongst communities such as farmers, villagers, an urban housewife community, etc. Relatively little research has been done on the "forced" diffusion of change which occurs in an organisation structure when management decides to introduce an innovation.

This thesis sets out to present a model of the process of diffusion of Management Science in South African business. This area has been researched internationally and there are a number of publications relating to the diffusion of Management Science activity in government and commerce in America and Europe. The main body of this thesis is devoted to an examination of the published findings on the diffusion of Management Science, together with an analysis of the data obtained in ten case studies carried out on Management Science activities in South African companies.

This chapter presents a summary of one of the general theories of innovation diffusion, as many of the concepts and findings form an important foundation for the derivation of the Management Science diffusion model.

which one?

INTRODUCTION

The main purpose of this thesis is to propose a process, or model, of the manner in which a relatively new concept in Management, Operations Research or Management Science, is likely to be adopted by South African business. The model is based upon the results of similar research carried out in America, and is tested against data obtained in field studies performed in South African companies.

The main difficulty involved in transferring data obtained in America to South Africa, lies in the differences in environmental and sociological conditions which exist between countries. These are often so great that it is not possible to transpose the results, or findings, from the one country to the other without further research. South Africa, like other industrialized and semi-industrialized nations, has its own Business Character which must be identified before any American data can be used.

There are many factors which influence the development of the Business Character of a nation. For example, research has shown that stronger economic growth and a quicker response to new opportunities appears to be present in countries in which the "desire to achieve" has been encouraged from childhood.[1] Conversely, in countries where individuals are not provided with this motivation to achieve, business enterprise and economics tend to lag. Individuals in these environments appear to be reluctant to adopt new technology and new practices. The need

for achievement in a country has been identified as an essential motivating force and one which will significantly influence the attitudes of executives towards new concepts in management. It is therefore essential to clearly understand the difference in management attitudes which exist between America and South Africa.

The process by which new ideas and practices - innovations - are transmitted from one individual to another is in itself complex and must also be examined before any study of this nature can be attempted. The process of the transmission of Innovation is called Diffusion and this has been the subject of extensive research during the past ten years. Much of the research has been directed to fields such as Consumer Behaviour, as it is here that Innovation Diffusion is of particular importance.

Probably the earliest and best known models of Innovation Diffusion was called the "Trickle Down Theory". This model related primarily to the diffusion of women's fashion and was concerned with the manner in which new fashions appear to filter vertically down by stages through various levels of affluence. The "Trickle Down Effect" was first proposed in 1904 by Simmel, a sociologist, and was subsequently extended by Dwight Robinson in 1961[2] Robinson modified the vertical flow concept to include horizontal movement within particular social strata.

The Trickle Down or Vertical Flow hypothesis postulates

that the

> upper socio-economic classes adopt fashions first in the time dimension as symbols of distinction and exclusiveness. In the course of inter-intra class competition, the lower classes, each and in turn accumulate and follow the upper class leaders. At a certain level of adoption by the lower levels, the syndrome of styles becomes vulgarized and is discarded by the upper class in favour of a new set of fashion symbols. The trickle is again activated and the process repeats itself.[3]

The Vertical Flow hypothesis was challenged by C.W. King in an article entitled "Rebuttle to the Trickle Down Theory".[4] King examined the whole process by which fashions are merchandised and marketed in America. He proposed an alternative model - the "Trickle Across" model - which hypothesised that information regarding fashions flows horizontally within social strata rather than vertically down. Fundamental to King's model was the concept that the early purchasers of womens' fashion - the Innovators - were not an elite set of fashion conscious upper class women but rather groups located within each of the various levels of social strata.

Innovators play an important role in determining the acceptance or rejection of fashion. If the Innovators adopt a new style this is the earliest sign of consumer acceptance and it may precede adoption by the mass market.[5]

At the time King proposed his Trickle Across model, other researchers were working in the general area of Innovation Communication. This research was directed primarily at the identification of the process by which information from the mass

media reached the consumer. One of the results of this research was the development of the "Two-Step Flow Model", which argued that communication of this type is not all vertical i.e. direct from the mass media down to the consumer. The Two-Step Flow Model postulates a vertical step from the mass media to individuals identified as "Opinion Leaders" followed by a horizontal step from them to the others.[6]

The Opinion Leaders proposed here were not the Innovators that King had identified. In effect, the Innovators are the first to adopt a new idea promoted by the mass media. Once the Innovators promote an idea, Opinion Leaders become aware of it. If they feel that the idea has merit or logic, they may try it and it is at this point that the mass market becomes involved.[7]

Innovation Diffusion research has not been confined to the introduction of women's fashion. During the past twenty years much work has been done on the social and cultural dynamics associated with technological change. This research has become particularly important during the last five years as a great deal of it has been aimed at improving social and living conditions in underdeveloped countries. The reported research includes projects such as the Introduction of Hybrid Corn to Mexican Farmers,[8] Soil Conservation in Navajo Indian Reservations,[9] and Green Manuring in Pakistan.[10] The fundamental problem in all programmes of this nature is the early anticipation of adverse reaction in a population subjected to change.

McClelland's work on "the desire to achieve" has already been mentioned.[11] This is only one of the many inherited and cultural traits that combine to form a national identity and an attitude towards change. The collective attitudes of a group of people drawn together for a specific purpose are called Values. Feldberg defines Values as "beliefs or ideas which people hold as an ideal. They are broad objectives that, while describable, are never fully attainable."[12] A group of individuals involved in a problem-solving exercise will develop a set of Values which will subsequently govern their reaction to a particular type of change. In addition to their values the group will also have Norms which are a form of emergent behaviour that the group believes is desirable. Norms are more general than Values as they can generally be measured.[13]

In order to predict the manner in which a group of farmers or businessmen will react to an Innovation it is necessary to have an understanding of the Norms and Values of the group. Published research shows that many worthwhile innovations have failed because the Norms and Values of the communities into which they were introduced were never considered.

The Diffusion of Innovation into an organisation represents a particularly complex diffusion process. Normally it is first necessary for a member of Top Management to take the decision to introduce an innovation before subordinates are forced to adopt it. This forced adoption causes many problems which can subsequently result in the rejection of the innovation.

The introduction of computers into business during the period 1955 to 1970 was a typical example of this type of Innovation Diffusion.

This thesis deals with the Diffusion of Management Science in South African business. The empirical model derived in the thesis is based upon the results of similar studies carried out by a research group that has spent the last fifteen years tracing the history of Management Science diffusion in American Organisations. In order to gain a better understanding of the results of this research, it is first necessary to examine a general model of the process of Innovation Diffusion in some detail.

The model that has been selected is one proposed by Rogers and Shoemaker. This model was chosen because it is extremely well documented and has been extended to include diffusion of innovation in organisations. It is fairly easy to correlate the general concepts of Rogers and Shoemaker with the specific Management Science model.

The Rogers and Shoemaker model is described in summary in the following sections. It must be stressed that the summary is only designed to provide the reader with an overview of the concepts of diffusion. This is a useful benchmark with which to subsequently evaluate the more specific Management Science Life Cycle model.

THE ROGERS AND SHOEMAKER DIFFUSION MODEL

The main elements involved in the diffusion of a new idea are the following:

A. the Innovation itself
B. which is communicated through Channels
C. over Time
D. to members of a Social System.[14]

The Innovation[15]

An innovation can be regarded as an idea, practice, or object perceived as new by a social system. The innovation need not be new in time, but it will be regarded as new by the community into which it is introduced. The characteristics of an innovation determine the rate at which it will be accepted or "adopted" by the community. There are five fundamental characteristics to consider when the possible attraction of an innovation is assessed.

1. The "Relative Advantage" of the innovation defines the degree to which it is perceived as being better than the idea it supersedes. The greater the Relative Advantage of an innovation the greater its chances of adoption.

2. The "Compatibility" of the innovation defines the degree to which an innovation is perceived as being consistent with existing values. Here again, the greater the Compatibility the greater the chances of adoption.

(3) The "Complexity" of an innovation defines the degree to which it is perceived as being difficult to understand. There is a negative correlation between complexity and rate of adoption.

(4) The "Trialability" of an innovation defines the degree to which an innovation may be experimented with on a limited basis. There is a positive relationship between Trialability and rate of adoption.

(5) The "Observability" of an innovation defines the degree to which results are visible to members of a social system. In this case there is a positive relationship between Observability and rate of adoption.

These five factors can be evaluated individually and used to forecast the possible chances of adoption. However it has been found that an unfavourable rating for a single factor might be enough to prevent the innovation being accepted.

(B) Communications Channels[16]

These are the means by which information relating to the innovation is transmitted to members of the social system. Channels provide the vehicle for getting communication from one person, or institution, to another. The person providing the communication is called the "source", the person hearing the communication is the "receiver".

Channels are usually categorised as being either "interpersonal" involving a face-to-face exchange between two or more persons, or "mass media" in which a source of one or more individuals reaches a receiver of many. Typical mass media channels include radio, newspapers, television etc. In the context of this thesis the most important of the two channels is interpersonal communication. However in a more general context, mass media channels are of fundamental importance.

Time

The third element that must be identified in any study of diffusion is the relationship between Time and the Innovation-Decision process.[17] This is the mental process by which an individual passes from his first knowledge of an innovation to a decision to adopt or reject it. Adoption defines the decision to make full use of a new idea as the best course of action. Rejection is the decision not to adopt the innovation, whilst discontinuance refers to a subsequent decision to cease using an innovation after previous adoption.

An individual goes through a series of stages in the innovation-decision process prior to adoption or rejection. This is a mental process and the stages that have been identified are:[18]

Awareness - individual learns of a new idea but has limited information about it

Interest - the individual becomes interested and seeks information about the innovation

Evaluation - the individual decides whether or not to try the innovation

Trial - the individual applies the idea on a small scale to determine its utility in his environment

The final stage is Adoption when the new idea is used continuously on a full scale basis.

A decision to Reject the innovation may occur at any stage of the process. For example, Awareness may be followed by immediate Rejection. Alternatively, the individual may be sufficiently motivated to follow the process through to the Trial stage, at which point the results of the trial may make him decide to reject the innovation.

The speed with which an innovation proceeds from its first introduction to an individual to its final adoption by that individual depends upon the "innovativeness" of the individual.[19] This expresses the degree to which an individual is relatively earlier in adopting new ideas than other members of his social system. There are five adopter characters relating to innovativeness and these can be classified in terms of five well defined human characteristics.

- Innovators (venturesome)
- Early Adopters (respectable)
- Early majority (deliberate)
- Late majority (sceptical)
- Laggards (traditional)

It is interesting to note that research has shown that Early Adopters are less likely to discontinue an innovation than later adopters.[20] Therefore an innovation may be rejected by a social system even though the Innovators and Early Adopters are completely satisfied with it.

This leads to the concept of the overall Rate of Adoption[21] of an innovation which is the relative speed with which it is adopted by members of a social system. Due to the presence of five classes of adopters the Rate of Adoption is not constant within a social system. In addition it is affected by a phenomenon known as the Diffusion Effect.[22] The Diffusion Effect is the increasing degree of influence upon an individual to adopt or reject innovations, resulting from an increasing awareness in the social system. For awareness under 30% there is virtually no adoption, once this stage is passed further increases in awareness lead to an increasing Rate of Adoption.

Social System[23]

The final aspect of the diffusion process that must be considered is the social system in which the diffusion takes place. A social system is a collectivity of units, each functionally differentiated from the other, which are engaged in joint problem solving with respect to a common goal. The structure of the social system can have an important influence on the spread of new ideas.

For example the Norms of a social system can significantly

influence of the Rate of Adoption.[24] There are two extremes in the classification of established behaviour patterns likely to be observed in members of a social system. A social system with Modern Norms will have members who are change orientated, technologically developed, scientific, rational and empathetic.[25] Members of a social system with Traditional Norms will be the exact opposite of their Modern Counterparts. A social system with Modern Norms will have a far higher Rate of Adoption than one with Traditional Norms. Rogers and Shoemaker use the word Norm to define established behaviour patterns which serve as a guide or standard for members of that social system.

In the context of a social system undergoing change, two types of individual must be defined as they are critical to the diffusion process.[26] There is the "Change Agent" who is generally a professional person who attempts to influence innovation decisions in a direction which he feels is desirable.

In addition there are individual referred to as "Opinion Leaders".[27] These are individuals who are able to influence the attitudes or behaviour of other individuals in a desired way with relative frequency. The individuals so influenced are referred to as "followers". Opinion Leaders in a social system with Modern Norms are highly innovative, whilst those in a social system with Traditional Norms are not.

THE ROLE OF THE CHANGE AGENT

In a social system which is not a business organisation, Opinion Leaders are an extremely important factor in the diffusion process. In an organization, opinion leaders are important, but in the majority of cases the decision to introduce an innovation has been taken at a higher level (this is discussed subsequently). It is the Change Agent or the person entrusted with the responsibility for introducing the innovation who has the greatest effect on its subsequent success or failure. The responsibility may have been designated by a higher authority, or may have been assumed if the Change Agent is motivated purely by what he feels are the interests of the company.

It has been found that there are certain criteria for success about which a Change Agent should be aware. The relationship between the Change Agent and his clients (the group whom the Change Agent is trying to influence) is of particular importance. The following stepwise Change Agent activity breakdown has been found to be positively associated with Change Agent success.

1. Develop a need for change on the part of the client.
2. Establish an effective relationship with the client.
3. Diagnose their problems with them.
4. Create the intent to change.
5. Translate the intent to action.
6. Stabilize change and prevent discontinuance.
7. Achieve a terminal relationship with the client.[28]

It is important to notice that at all times the Change

Agent acts in an advising position and does not attempt to enforce change. The last two steps are particularly critical in ensuring that once the innovation has been adopted, its continuing adoption is not dependent upon the presence of the Change Agent.

These steps indicate, and research has confirmed, that the attitude of the Change Agent can significant influence the chances of his successfully influencing the adoption of a new idea. Various factors have been found to have a positive relationship with successful adoption. These include:

- The extent of the Change Agent effort
- His involvement, empathy, and credibility with his client
- The degree to which he works through opinion leaders
- The degree to which the innovation is compatible with the needs of the client[29]

These findings relate to the general activities of Change Agents in a variety of social systems. Research into the diffusion of Management Science activity in American business has shown that the role of the Change Agent is crucial to the success of the introduction and adoption of Management Science. This is discussed in detail in Chapter 4, where the specific findings relating to Change Agent activity in Management Science situations are examined in the light of general information presented in this section.

The diffusion of Management Science is complicated by the fact that Management Science groups are generally introduced as staff support functions in an organization. The use of this support is usually left to the discretion of individual departments. As a result the Management Science group may be totally ignored unless a senior executive decides to promote their activities and acts as the Change Agent or "Sponsor". It has been found that there are often fairly definite advantages associated with sponsorship of Management Science activities and sponsors often gain more in the process than the Management Science group.

AUTHORITY-INNOVATION DECISION SITUATIONS

The decision to adopt or reject an innovation is usually dependent upon the environment in which the decision is made. Most research relating to the diffusion of innovation has concentrated on two types of decisions.[30] The most commonly occuring decision situation is the "Collective Decision" in which the individuals in a social system agree to do something by consensus of opinion. This is often followed by a series of "Optional Decisions" which are made by individuals regardless of the decisions of other members of the system. For example a farmer's co-operative may agree to introduce a new type of seed hybrid (Collective Decision), and yet the actual use of the hybrid must depend upon individual farmers who may or may not adopt the Collective Decision (Optional Decision).

There is a third type of decision situation called an Authority Decision in which an individual in a power position

forces an individual in a subordinate situation to comply with the decision taken by the superior. Authority Decisions are typical of the decisions taken in organizations where a manager may decide to adopt (reject) an innovation and as a result enforce the adoption (rejection) of the innovation on all his subordinates. Unfortunately relatively little research has been done on the subject of Authority Decisions.

The following characteristics distinguish Authority Innovation decisions:[31]

1. The individual is not free to exercise his choice in adopting or rejecting the innovation.

2. Decision making and adoption are activities of two separate individuals or units.

3. The decision unit occupies a position of higher authority in the social system than the adoption unit.

4. Because of this hierarchical relationship between the decision unit and the adoption unit, the decision unit can force the adoption unit to conform to its decision.

5. Authority-Innovation decisions occur more frequently in formal organizations than in informal social systems.

> A formal organisation is a social system that has been deliberately established for achieving certain predetermined goals; it has been characterised by prescribed roles, an authority structure, and a formally established system of rules and regulations which govern the behaviour of its members.[32]

same heading as the last one?

The Innovation-Decision Process in Authority Decisions

Certain fundamental generalizations have been made concerning Authority-Innovation Decisions. These relate to the various stages of the innovation-decision process.

Awareness - Here the decision unit becomes aware of an innovation which will be destined for later trial by the adoption unit. Alternatively there may be an upward flow of innovation-awareness from subordinates to superior.

"A supportive relationship between the adoption unit (a subordinate) and the decision unit (a superior) leads to more upward communication about the innovation."[33]

Evaluation - At the evaluation stage a formal choice is made by the decision unit whether or not to try innovation. It has been found that the most important aspect in innovation evaluation is the degree to which the adoption unit participates in the evaluation process.

"An individual's acceptance of an Authority-Innovation decision is positively related to his participation in innovation decision-making."[34]

These two generalizations highlight the fundamental differences in the two basic approaches to organizational change:[35]

1. The "Authoritative" approach in which there is an unequal distribution of power. Decisions about change are made by persons with high formal authority.

2. The "Participative" approach in which there is wide sharing of power. Decisions about change are made in consultation with those affected by change.

The former approach is more common in business and particularly in businesses with Traditional Norms.

Two final generalizations highlight the problems associated with these two different attitudes towards change in Authority-Innovation Decision situations.[36]

"The rate of adoption of Authority-Innovation decisions is faster by the Authorative approach than by the Participative approach."[37]

"The probability of discontinuance of an Authority-Innovation change is higher when it has been introduced by means of an Authoritative approach than it is when the change is introduced by the Participative approach."[38]

Clearly the Authoritative approach results in a more rapid adoption of innovation, however the downside risk of this

approach is the greater chance of subsequent discontinuation. This problem of conflicting approaches often becomes the headache of the Change Agent who has been delegated the responsibility of introducing the innovation and ensuring its adoption. It is interesting to note that the points listed in a previous section relating to optimal Change Agent attitudes depict the Participative approach rather than the Authoritative.

CONCLUSION

This thesis is concerned with the diffusion of Management Science in South African business. A substantial amount of research has been conducted in this area internationally. The findings relate mainly to the diffusion of Management Science in large organizations. In order to anticipate possible modifications due to a different business environment in South Africa it is important to examine the Theory of Diffusion in Innovation in more detail.

This chapter has been devoted to an examination of the main aspects of Innovation-Diffusion Theory which have been developed during the past 15 years by Rogers and Shoemaker. Although the theory applies more to diffusion in social systems rather than formal organizations, the fundamental concepts do provide a very important foundation with which to examine the diffusion of innovation in organizations.

There are four elements involved in the diffusion of an innovation

1. the Innovation
2. which is communicated through Channels
3. over Time
4. to members of a Social System

The innovation may be adopted or rejected by the members of the social system. Its chances of adoption are influenced by criteria such as Relative Advantage, Compatibility, Complexity, Trialability and Observability. Information relating to these criteria is transmitted through the social system by means of communication channels either interpersonally or via mass-media.

It is postulated that an individual passes through four mental states prior to deciding whether or not to adopt an innovation - awareness, interest, evaluation, and trial. The innovation may be rejected at any stage during the process. The speed with which an individual passes through these states is dependent upon his Innovativeness. An individual may be classified either an an Innovator, Early Adopter, Early Majority, Late Majority, or Laggard depending upon his level of innovativeness.

As a result the overall Rate of Adoption of an innovation is very much dependent upon the relative percentages of the different types of individual in a particular Social System. The Norms of a social system can also significantly influence the chances of adoption of an innovation. A social system with Traditional

norms will not adopt innovations as easily as a system with Modern norms.

Furthermore the attitudes of the individuals within a social system towards an innovation will be very much affected by the activities of the Opinion Leaders and Change Agents in the system. Change Agents in particular can influence the attitudes of individuals within the social system by the manner in which they promote the benefits of the innovation.

In a formal organization structure the decision to introduce the innovation is usually forced on members of the organization by an individual in a power position. In this situation the decision-making and adopting activities are located in different individuals. This is typical of Authority Decision making, and is of particular interest in this context in view of the fact that their approach is often used to introduce Management Science activities into organizations. Apart from the specific work done by the Management Science Research Group, there is not a great deal of research available in the general area of Authority-Innovation Decisions.

Two fundamental approaches to organisational change have been found to significantly affect the outcome of Authority-Innovation Decision situations. An Authoritative approach towards Authority-Innovation decisions results in faster adoption than would be achieved if a Participative approach was adopted, however the chances of discontinuance are greater.

These basic concepts of the theory of Innovation Diffusion will subsequently be used in conjunction with the findings of the Group investigating the Diffusion of Management Science to present a model of the Diffusion process of Management Science activities in South Africa.

REFERENCES

CHAPTER 1

1 D.C. McClelland, "Business Drive and National Achievement," Harvard Business Review, July/August 1962, pp. 99-112

2 C.W. King, "Fashion Adoption: A Rebuttal to the 'Trickle Down Theory'," in Dimensions of Consumer Behaviour, ed. by J.U. McNeal (New York: Appleton-Century Crofts, 1969), p. 170 citing D.E. Robinson, "The Economics of Fashion Demand," The Quarterly Journal of Economics, 75:3, 1961, p. 376, and G. Simmel, "Fashion," The International Quarterly, Vol. X, (October 1964), pp. 130-155

3 Ibid., p. 171

4 Ibid., pp. 169-184

5 J.U. McNeal, An Introduction to Consumer Behaviour (New York: John Wiley & Sons, Inc., 1973), pp. 119-120

6 P.D. Burnett and H.H. Kassarjian, Consumer Behaviour (Englewood Cliffs, New Jersey: Prentice Hall Inc., 1972), pp. 104-106

7 J.U. McNeal, op cit., p. 120

8 E.H. Spicer (Ed.), Human Problems in Technological Change (New York: John Wiley & Sons Inc., 1965), pp. 35-41

9 Ibid., pp. 97-113

10 Ibid., pp. 55-69

11 D.C. McClelland, op cit., pp. 99-112

12 M. Feldberg, Organizational Behaviour: Text and Cases (Cape Town: Juta and Co., 1975), p. 74

13 Ibid., p. 74

14 E.M. Rogers and F.F. Shoemaker, Communication of Innovations. A Cross-Cultural Approach (New York: The Free Press, 1971), p. 39

15 Ibid., p. 167

16 Ibid., p. 266

17 Ibid., p. 99

18 Ibid., p. 101

19 Ibid., p. 181

20 Ibid., p. 133

21 Ibid., p. 181

22 Ibid., p. 168

23 Ibid., p. 40

24 Ibid., p. 40

25 Ibid., pp. 31-34

26 Ibid., p. 225

27 Ibid., p. 226

28 Ibid., p. 229

29 Ibid., p. 230

30 Ibid., p. 296

31 Ibid., p. 302

32 Ibid., p. 303

33 Ibid., p. 307

34 Ibid., p. 308

35 Ibid., p. 313

36 Ibid., p. 313

37 Ibid., p. 314

38 Ibid., p. 314

CHAPTER 2

AN APPRECIATION OF MANAGEMENT SCIENCE

Management Science is currently classed as an innovation, particularly in the South African environment. It is difficult to establish precisely when the first instance of the application of a Management Science technique occurred, but it is known that the first formal Management Science groups were established in Britain in 1937. The discipline has subsequently been adopted in most industrialized nations and has been credited with an impressive list of successes. However there have been instances of failure or discontinuation, and there is still some confusion regarding the true nature of Management Science.

This chapter presents a brief review of the history of Management Science, its origin and its development during the last thirty years. A series of definitions of Management Science are discussed and a working definition is proposed which is orientated towards techniques rather than concepts. This type of definition is essential in view of the difficulties involved in locating Management Science activities which are identified by different organizational names. The more commonly occurring Management Science techniques are listed together with possible areas of application.

Finally the link between Data Processing and Management Science is examined and the interdependency of the two innovations established.

THE HISTORY OF MANAGEMENT SCIENCE

Scientific Management Methods Prior to World War II

Although there have been many examples of the application of scientific method to solve non-scientific problems probably one of the most important events occurred in 1910 when Frederick Winslow Taylor wrote the book "Scientific Management."[1] His recommendations were based upon the observations of the duties of shop foremen and workers. He established standards for workers and introduced the concept of specialization. Taylor presented six principles of scientific management among which were included:[2]

- Management must use the scientific rather than the rule of thumb approach.
- The best means of economical production has to be chosen.
- Specialization of workers has to be obtained with the aim of increasing efficiency of production.

Whilst Taylor was evaluating specialization, Henry L. Gantt was working on problems in production scheduling.[3] Gantt sought to plan the loading of production machines so that bottle-necks were eliminated and production delays were reduced.

Frank and Lillian Gilbreth used the work of Taylor and Gantt to introduce the concept of motion study.[4] Motion study broke work down into small elements in order to eliminate waste-fulness as a result of unnecessary or inefficient motion. Using the results of motion study it was possible to redesign or

restructure jobs so that the worker became more productive and expended less effort.

The work of Taylor, Gantt, and the Gilbreths had an immediate impact on the business environment, particularly at the level of the shop floor. At the same time, a Frenchman, Henry Joseph Fayol wrote a book on the principles of general management called "Administration Industrelle et Générale".[5] Fayol was more concerned with the higher levels of management and his work was complementary to Taylor who was more involved with the workers themselves. The impact of this book was not felt immediately, and it was only twenty years later that the importance of Fayol's work was recognised.

In the years between 1910 and the Second World War several individuals contributed to the development of the discipline which subsequently came to be known as Management Science.

Frederick Lanchester in his book "Aircraft in Warfare, Dawn of the 4th Arm"[6] proposed his Linear and Square Laws which relate to the effect of concentration of forces on military strategy. A Danish engineer, A.K. Erlang,[7] investigated the fluctuation in demand for telephone facilities in automatic exchanges and established the mathematical theories upon which modern queueing theory is based.

Probably the first business application of scientific techniques occurred during the 1930's when an American,

H.C. Levinson, used mathematical techniques to model complex systems and manipulate large quantities of data.[8] He examined, for example, the rejection rate of COD packages and was able to establish a set of criteria to minimize rejection. Levinson and Brown carried out a study at Bambergers in Newark, New Jersey in 1935 and built a mathematical model to predict the number of shoppers as a function of advertising expenditure.

However, growth was haphazard, techniques were used by isolated individuals and managers generally solved their problems by experience. World War II provided a firm foundation for the disciplined and balanced growth of Management Science.

World War II and the Formation of Operational Research Groups

Although the need for scientific problem solving techniques was acute in the business environment it was far more urgently required in the military. In the twenty year gap between the 1st and 2nd World War military tactics and strategy had been unable to match the tremendous developments and increasing complexity of technology.

The first positive attempt to formally introduce scientific attitudes into the military environment occurred in 1937.[9] Sir Robert Watson-Watt launched the first two studies of the type that subsequently became known as "Operations Research" by recruiting small teams of scientists from all disciplines to work on military problems. Two years

later, in 1939, a few days before the outbreak of war Professor P.M.S. Blackett took charge of a group stationed at Baudsey which consisted of three physiologists, two mathematicians, two mathematical physicists, an astro physicist, a surveyor and a military man. This group was extremely successful in its investigations relating to the improved use of radar in the tactics of air defense. Radar in the field had not proved as effective as laboratory studies originally indicated. "Blackett's Circus" achieved significant improvements to the power of radar. This led to the introduction of additional Operational Research groups in Fighter Command, as well as at Admiralty and Army Operational Headquarters.

Sir Robert Watson Watt[10] recommended that the United States introduce similar teams into the departments of the Secretary of War and the Secretary of the Navy. Study groups travelled from the United States to Britain in 1941 and by April 1942 the US had formally introduced Operations Research (OR) at a high level. The use of these OR teams spread to Canada and France. Teams were generally assigned to the executive in charge of operations and their work became known as Operational Research in Britain and by a variety of names in America - operational analysis, operations evaluation, operations research, systems analysis, systems evaluation, systems research, and management science.[11] Management Science has generally come to be regarded as the application of OR techniques in the business environment.

During the war OR groups investigated a variety of problems. Amongst these were the following:[12,13]

(a) the co-ordination of radar installations with range finders at anti-aircraft batteries;

(b) the investigation of techniques used to detect and destroy enemy submarines. These were successful in greatly increasing the percentage of submarines destroyed;

(c) the establishment of an optimal convoy size to reduce losses through submarine attacks.

Operations Research After World War II

At the end of World War II the state of the economies of the United States and Britain had very different consequences on the development of OR in the two countries.[14,15] Much of Britain's manufacturing facility was obsolete or had been severely damaged by German bombs. In addition the nationalization policy adopted by the Labour Government resulted in the recruitment of many operational research workers to work on governmental and industrial problems at a national level. The coal, iron, steel, and transport utilities began to create industrial Operations Research groups of their own. During the mid 1950's the ranks of the "military" industrial operations researchers was swelled as a result of greatly increased demand when the record achieved by the early groups indicated the success of Operations Research attitudes. Large companies such as United Steel, National Coal Board, British Petroleum etc. each employed more than 40 OR personnel by 1960.[16]

Defense research was increased in the United States after the war and military OR itself grew considerably. Most of the experienced OR workers remained in the service of the military. American industries did not require assistance as there was no need for the major reconstruction of plant. For example, the United States Navy OR activity which is termed the OEG (Operations Evaluation Group) carried out research on:[17]

(a) The defence against nuclear and ballistic missile attacks.
(b) The effect of such attacks on fleet formations.
(c) The optimization of US Navy missiles in defence and attack.

Subsequent work by the OEG included reports on topics such as "measures for protection of overseas transport".

It was the Second Industrial Revolution that in fact brought about the involvement of Operational Research in American industrial problems. World War II brought significant advances in the study of communication, control, and computation. These formed the basis of automation - the replacement of man by machines as a source of control. Electronic computers became commercially available in the early 1950's and this, together with the outbreak of the Korean War, resulted in greater demands on productivity in American industry. The computer brought with it a host of new systems problems for which no past experience was wholly adequate. Existing management were not capable of handling these problems and military OR men who had spent 10 years in the field handling similar problems began leaving for positions in industry and university.

By 1960 there were as many non-military OR workers as there were military. Over 50% of the top 500 US companies had formal Operations Research groups and the number has subsequently increased. The American Operations Research Society held its first meeting in 1953 and in 1957 the International Federation of Operational Research was founded. Universities and Business Schools in America and abroad began offering Operations Research at degree level.

The data in Table I highlights the rapid increase in membership of the Institute of Management Science, which is an American Society, and the Operational Research Society, which is British, over the period 1953 to 1973.

T A B L E 1

MEMBERSHIP DETAILS FOR THE INSTITUTE OF MANAGEMENT SCIENCE AND THE OPERATIONAL RESEARCH SOCIETY 1953-1973[18]

Institute of Management Science (USA)		Operational Research Society (UK)	
1953	235	1953	Not available
1958	1 600	1958	Not available
1963	2 700	1963	961
1973	6 559	1973	3 161

Even though there was a large movement of OR personnel to industry both in America and Britain, Operations Research is still very evident in the military. Many defense industries are required to carry out OR research. This has brought about the growth of think factories and advanced systems programmes which in turn has increased the demand for Operations Research and systems analysis. OR itself has become an important technique in the creation and evaluation of tenders and contracts. OR groups were used extensively in the NASA space projects during the late 1960's and early 1970's.

DEFINITIONS OF MANAGEMENT SCIENCE

Examination of Historical Definitions

The variety of names used to describe the activity classically known as Operations Research clearly shows that there is a great deal of uncertainty over the precise boundaries of what is and what is not Operations Research.[19] In America particularly the activity is more commonly referred to as Management Science which seems to be a more meaningful title. However it is also called operational analysis, operations evaluation, systems analysis, systems evaluation or systems research. It is therefore inevitable that there have been as many definitions of Management Science and it is interesting to note that as yet there is no agreement on any single definition. Current research in America and Britain has shown that Operational Researchers or Management Scientists have very different ideas on the nature of their work. At this moment

in time there is a great deal of uncertainty regarding the most desirable directions for growth.

As the subject of this thesis is an evaluation of the process of the diffusion of Management Science in South Africa it is essential that a definition of the activity in an international environment be established. Subsequently this definition will be used to identify Management Science activities in South African business.

Morse and Kimball produced probably the first and best known definition of Operations Research in 1951.[20] "Operations Research is the application of the scientific method to provide executives with a quantitative basis for decisions regarding operations under their control." Although most authors in the field accept this reference, many take exception to it as being too narrow in scope. Thierauf and Grosse[21] for example comment

> Instead of using Operations Research in this definition, replace it with another discipline such as cost accounting and see what happens. The definition applies to cost accounting as well as other disciplines. Thus the definition is deficient since it does not distinguish Operations Research from a number of other disciplines.

Although this is acceptable criticism it immediately highlights the problems facing anyone trying to produce a concise definition which completely describes the field. One of the best known books on elementary Operations Research by Churchman, Ackoff and Arnoff increases the scope of the definition considerably but still fails to cover all the areas involved.[22]

> OR in the most general sense can be characterized as the application of scientific methods, techniques, and tools to problems involving the operation of systems so as to provide those in control of the operations with optimum solutions to their problems.

Although the authors do subsequently introduce the concept of multidisciplinary teams it is not part of the definition. Note that this definition is concerned with the operation of systems, an area which operations researchers identify as their sphere of operation more and more in the 1970's.

Stafford Beer, who is the doyen of Operations Research in Britain, produced a definition of OR in 1959[23] which was subsequently adopted by the British Operational Research Society in 1962.

> Operations Research is the attack of modern science on complex problems, incorporating measurement of factors such as chance, and risk, with which to predict and compare the outcome of alternative decisions, strategies and controls. The purpose is to help management determine its policy and actions scientifically.

This definition introduces the concept of uncertainty and also highlights the selection of a course of action from a number of possibilities by comparison of the results obtained for a list of alternatives. Beer's definition also stresses the "complexity" of the decision situation and this attitude is also encountered in an essentially simple definition produced by the International Committee on Operations Research in 1969. "OR is the application of the scientific method to the study of operations of large complex organisations or activities."

At this stage we become more aware of the particular importance of OR as a means of forecasting the outcomes of decision situations in an environment which is far too complex for the manager to resort to classical intuitive decision making. In this environment decision making has to rely on scientific techniques for assistance. Obviously in this type of situation the mass of data alone often necessitates the use of statistics and mathematics for analytical purposes. It is perhaps useful to recall that OR came into being at a time when existing military skills were unable to make decisions in highly technical environments. Here the accent was more on the provision of OR support groups to supply the military strategist with the technical backup required to make decisions. In the business environment the Operations Research support is used to provide the businessman with a method of obtaining useful information in highly uncertain situations or when sheer volume of data involved makes it difficult or impossible to select optimum alternatives.

The complexity of decision making becomes more evident when one remembers that decision making at relatively low levels in the organisation can result in an optimum decision being taken for a department or division whilst the overall effect on the organisation is sub-optimal. Obviously if the decision-making process is operating in a large or complex system it must ensure that the decision taken is best for the total system and here a definition by Ackoff and Sasieni[24] sums up the situation fairly neatly:

Ackoff + Sasieni 1968

"(a) The application of scientific method.

(b) By interdisciplinary teams.

(c) To problems involving the control of man-machine systems so as to provide solutions which best serve the purposes of the organisation as a whole."

This definition is as weak in establishing the meaning of scientific method as the original taken from Morse and Kimball. However it does sum up the main areas which are thought to be characteristics of Operations Research.

Thierauf and Grosse produced a definition in 1970[25] which seems to fit the classical concept of Operations Research best. With the advantage of hindsight it seems strange that it took twenty five years since the emergence of Operations Research as a discipline to arrive at a reasonable description of the activity.

Operations Research uses the planned approach "Scientific Method" and an interdisciplinary team in order to represent complex functional relationships as mathematical models for the purpose of providing a quantitative basis for decision-making and uncovering new problems for quantitative analysis.

This definition is interesting as it identifies scientific method as a "planned approach" and introduces the concept of mathematical modelling for the first time. Unfortunately the definition really only applies to the textbook or classical OR situations and recent developments in America have indicated that in practice the situation is very different. The most significant problem facing anyone working in the field is that many people doing true OR work are not aware that they are classed as Operational Researchers. Furthermore many formal OR groups do not work according to the definition.

It is only after tracing the changes in the definition during the past twenty five years that one can begin to understand how many different schools of thought must exist regarding OR. It is interesting that whilst Morse and Kimball ignored the concept of interdisciplinary teams only six years after the end of World War II, Thierauf and Grosse reintroduced it twenty years later. Here is an area which permits little clarity and raises some crucial questions. These range from the simple "can an individual practice OR?" to the far more complex "can a group made up of people with OR undergraduate degrees be regarded as an OR team as they do not fulfil the interdisciplinary requirement?"

A Working Definition of Management Science

In addition to the problems associated with the definition of Operations Research the uncertainty has been compounded by the many names that have been used to denote OR-type activities. Probably the most frequently used term which is taken as synonymous with Operations Research is "Management Science". These two names have been used interchangeably since the early sixties. By definition, Management Science refers to the application of OR techniques in the field of management. A problem arises when an attempt is made to classify the use of recognised OR concepts in an extremely complex inventory problem in which company marketing and production strategies are concerned. It is difficult to see where OR ends and Management Science begins.

The articles published in the Journal of Management Science and the Journal of the Operations Research Society of

America indicate that the two societies have a great deal in common. The similarity between the activities covered by the two terms has led researchers in the area to refer to the overall activity as "Operations Research/Management Science" or in its abbreviated form "OR/MS". This serves to a certain extent to minimize the subtle differences in nomenclature that exist.

The early growth and subsequent maturity of OR/MS has been the subject of a prolonged investigation which started in the early sixties. The study is entitled "Research Program on the Adoption and Diffusion of Operations Research/Management Science activities in Business and Government Organisations: United States and Overseas". It is headed by two faculty members at Northwestern University, Evanston, Illinois, USA - Professors Michael Radnor and Albert Rubenstein. The research programme has been adopted by individuals at universities in many countries and members of the programme have published their findings extensively.

In 1968 Radnor, Rubenstein and Bean[26] carried out a survey of OR/MS activities in 66 United States companies. These were all members of the Fortune listing of the top 500 American companies. In order to identify their area of study the authors took the following as a working definition of OR/MS activities

> ... which are performing work utilizing the newer methods of mathematical analysis and/or who are involved in non-routine computer systems activities. These activities are labelled with various organizational names such as operational research, management science, systems analysis and similar names.[27]

Radnor and Rubenstein proposed OR/MS as a generic name to cover these separate but related areas.[28]

This definition is critical to this thesis. It is not as rigorous as some cited in the previous section but it does serve as a practical guide to the identification of OR/MS activities. In the South African environment the Operations Research Society is in its infancy, there has been little formal education in OR/MS, and there are many users currently employing classical OR techniques who would be surprised if they learned that they could be considered Operational Researchers.

Ten in-depth studies were carried out in OR/MS environments, identified on the basis of the Radnor-Rubenstein definition. Of these ten situations only two were formally acknowledged OR/MS groups, the remainder relate to groups operating in functional areas such as production control, EDP etc. In time these remaining groups may be labelled OR/MS but for the present it suits management that they be identified by the functions in which they are housed.

As a result it is necessary at this stage to identify those techniques of mathematical analysis which are normally associated with OR/MS and thus, by identification of the users of these techniques in industry, be in a position to decide whether or not an OR/MS activity exists within an organisation.

Ackoff and Rivett,[29] as early as 1963, produced a comprehensive list of OR/MS techniques when they classified eight basic management problems which singly or in a combination account for the majority of problems which confront executives. Since the time the list was produced other techniques have been introduced to handle

other fundamental management problems. These will be discussed subsequently.

(i) Allocation Problems

Deal with the allocation of scarce resources to a number of activities which can be performed in a variety of ways. The situation becomes more complicated if the resources or facilities are not available for performing each activity in the most effective way. The problem is to combine activities and resources in such a way to maximize effectiveness.

OR techniques used here can be broadly defined as mathematical programming:

- Linear Programming
- Non-Linear Programming
- Stochastic Programming
- Dynamic Programming

Simulation

The techniques differ in the type of problem to which they apply and the assumptions that are needed in order to reach solutions.

(ii) Replacement Problems

There are two types of replacement problem, in the first instance items degenerate over a period of time (machines and tools) and in the second items fail after use or time (light bulbs). The problem is to balance the cost of early replacement against the cost of shutdown or loss of production.

Replacement problems are best handled by:

- dynamic programming
- calculus or statistical theory Simulation

(iii) Inventory Problems

Generally inventory control problems involve the balancing of the costs of maintaining stock against the cost of not having goods immediately available. Stocks may involve men, money, materials or machines and they will always represent money which is lying idle. OR/MS has been particularly active in this area and a large number of models exist which are designed to handle a variety of situations that occur in practice.

Many mathematical techniques have been put to use in Inventory Control situations, the most common are:

- Statistical and Probability Theory
- Mathematical Programming
- Simulation

(iv) Sequencing and Co-ordination Problems

In sequencing situations it is necessary to select the sequence in which a set of tasks can be optimally completed, whilst in co-ordination problems the sequencing aspect is already arranged and the problem is to allocate resources to each task so as to optimize the utilization of some resource.

Sequencing problems are difficult to solve by mathematical analysis and the best technique is:

- Simulation

Co-ordination problems are usually solved using several techniques which constitute the best known OR/MS methods in current use. Two of the most common are:

- Project Evaluation Review Technique (PERT)
- Critical Path Method (COM)

CPM ?

(v) Queueing Problems

The processing of queues in automatic telephone exchanges represents one of the earliest OR/MS applications. Queueing situations arise wherever a facility (such as a harbour or a crane) has to provide service to units (such as boats or bricks) which arrive more rapidly than servicing can take place.

Queueing problems can be solved using:

- Probability Theory
- Differential Integral Calculus

However during the last ten years the development of computer programming languages orientated towards queueing applications has led to increased use of:

- Simulation

Network algorithms

(vi) Routing Problems

In these problems there is generally a variety of ways in which a route can be constructed between a number of destinations called "Nodes". The problem is to find that sequence of Nodes which optimize the problem as stated by the decision-maker, i.e. minimize distance travelled.

A classical Routing problem is the so-called "Travelling Salesman Problem" where the objective is to minimize the distance travelled by a salesman who has to visit customers in a group of towns. Although this problem can usually be solved by inspection it is very difficult to solve using a general mathematical technique. Routing problems are best solved using:

- Iterative algorithmic procedures

(vii) Competitive Decision Problems

In this area the decision-maker is aware that the outcome of his decision will be significantly affected by the actions of an opponent or competitor who is also making decisions. This situation occurs in warfare as well as business, particularly in the field of marketing.

Although a great deal of work has been done in this area few really useful techniques exist. The best known method for solution of Competitive Decision Problems is:

- Game Theory

In practice it is found that only simple problems can be handled in this way. An alternative technique which is used more frequently is:

- Statistical Decision Theory

(viii) Search Problems

These problems are general to any situation in which the retrieval and identification of data is involved. The most frequently occurring analytical techniques used in search problems are:

- Statistical Sampling
- Estimating Theory

The Problems Associated with Classical OR/MS Techniques

OR/MS literature shows that these eight problem areas still exist although some new methods of solution have been introduced. Stafford Beer writing in 1966 commented that the techniques employed were probably best described as the "fruits of a quarter century of Operational Research experience."[30] He added that because the problems were so common and the techniques so frequently applied, it was possible to find good answers to management problems merely by substituting values in equations and calculating answers. There was no need to carry out Research, consequently none of the techniques required the services of a trained Operations Research analyst because the function of the analyst was "to do research that will establish answers to problems to which no answer at present exists."[31]

By Beer's definition the techniques which are used to solve problems in the eight areas listed previously can no longer be regarded as OR/MS but more a routine part of operating procedures. The true OR/MS man is the person who is no longer involved in the application of these techniques and is more concerned with the whole field of unsolved problems which confront managers today.

This definition poses a problem to anyone who is hoping to identify OR/MS in a business. It is theoretically invalid to classify an analyst using Linear Programming in a routine situation as an OR/MS worker.

Beer's feelings on what he felt an OR/MS analyst should be doing were shared by many of the founding fathers of Operations Research. The period 1965-1970 produced a series of articles by internationally known names examining the progress of OR/MS and trying to forecast future developments. A great deal of soul-searching went on to try to find the reasons for the apparent inability of Operations Research to develop along the lines that Beer had hoped it would. The titles of the articles themselves reflect the intensity with which the founders of Operations Research were examining the results of their labour:

"How can we improve Operations Research?"[32]

"Operations Research at the Cross Roads"[33]

"The Dilemmas of Operational Research"[34]

"Has Management Science reached a Dead End?"[35]

It is difficult to reconcile the views of David Hertz in particular whose optimistic book "New Power for Management"[36] published in 1969 contrasts significantly with the attitude displayed in the article "Has Management Science reached a Dead End?" which appeared in 1971.

In May 1971 Harvey M. Wagner addressed the annual convention of the Operations Research Society of America and chose as his topic "The A.B.C.'s of OR". Bearing in mind that this was five years after Beer had described "the fruits of a quarter century of Operational Research", there are a number of statements in Wagner's address which indicate how far OR/MS still had to go before the fruits were ripe for picking.

> The first paradox is that, although many industrial applications of OR are commonplace knowledge actually making these applications work is frustratingly difficult. ... an application may be standard yet it need not be routine.[37]

Wagner made the point that other disciplines under the Management Science umbrella were tackling problems that Operational Researchers had consciously reserved for themselves.

> The third paradox is that many daily operating problems that were recognised by Operations Researchers years ago as promising for the application of modelling are just now being tackled successfully by computer systems analysts, but not with the techniques provided by OR theory.[38]

In view of these problems it appears that the best approach is to carry on with the technique orientated definition proposed by Radnor, Rubenstein and Bean quoted at the start of this section. In the South African environment OR/MS techniques

are still in the implementation rather than the maturity stage and the situation is very much as Wagner described it.

Newer OR/MS Techniques

In the ten years that have elapsed since Ackoff and Rivett listed recognised OR/MS applications, other techniques have been developed which are proving extremely successful in attacking certain types of problems. Furthermore the increased power of computers has had a dramatic effect on the usefulness of some of the older techniques.

A technique known as Heuristic Programming has been found to be an extremely powerful tool in problem areas such as Project Scheduling,[39] Routing,[40] Warehouse Location,[41] as well as Inventory Control and Portfolio Selection. In the areas of marketing and financial management Model Building and Simulation techniques are being increasingly applied.[42,43] Within the past five years there has been an increasing effort to develop mathematical models of the entire firm. These are large scale computer simulation models and the primary purpose in constructing these models has been to learn how management activity can be explicitly modelled. Three of the best known models are the Systems Development Model, the Bonini Model, and Forrester's Industrial Dynamics.[44]

Model manipulation, using computer based models, to simulate environmental and business conditions has made significant progress in the past ten years and is regarded as one of the most interesting areas of OR/MS development. This has, in turn, laid

particular stress on the importance of being able to reduce organisational concepts to precise mathematical relationships and to be able to specify precise decision rules and procedures. The Systems Analysis aspect of OR/MS is assuming as important a role here as the Operations Research techniques themselves.

One of the results of this increased ability to model and simulate financial and organisational decision situations in large scale systems is a significant shift in the accent and appreciation of OR/MS since World War II. The OR/MS research group at Northwestern University has examined this shift by tracking the location of OR/MS activities in large American organisations over the past 20 years. Table 2 shows how the Research and Development/Engineering location of OR/MS has altered to Finance/Planning locations. It is reasonable to conclude that the type of assignments performed by these OR/MS activities has altered in a similar manner.

T A B L E 2

LOCATION OF OR/MS ACTIVITIES AT END OF PERIOD[45]

Location	1950-55 %	1956-59 %	1960-63 %	1964-66 %	1967-70 %
R & D	29	30	12	6	4
Engineering	18	12	5	4	-
Manufacturing	10	10	13	10	7
Finance	25	32	30	34	43
MIS/Admin	-	0	0	8	24
Top Management Planning	9	12	23	34	19
Marketing	0	0	0	0	2
Other	10	4	1	4	1
	100	100	100	100	100

Most Frequently Occurring OR/MS Techniques

Although the area of application of OR/MS has shifted in America during the last twenty years, one thing that has emerged from the work carried out by the Radnor/Rubenstein group is that only about six of the twenty or so recognised OR/MS techniques are used regularly and the remainder are encountered in special circumstances. Hence Beer's comment on the "fruits of OR" is also optimistic as many recognised OR/MS techniques are seldom encountered in practice. This is true all over the world and the data given in Table 3 for Britain, Japan and South Africa shows that six techniques in fact account for over 80 per cent of all OR/MS applications. The information was gathered in 1969/1970 and it is interesting to note that a relatively new technique such as Simulation (1961) has gained the same acceptance as Linear Programming (about 1953) and Statistics (pre World War II). The potential users of the techniques themselves have a significant influence on the degree to which they are utilized.

in what companies?

TABLE 3

MOST COMMONLY USED OR/MS TECHNIQUES

Technique	United Kingdom[46] %	Japan[47] %	South Africa[48] %
Statistics	20	26	18
Simulation	16	20	16
Linear Programming	10	15	12
CPM/PERT	18	14	18
Inventory Theory	11	6	13
Queueing	4	8	4
All Other	21	11	19
	100	100	100

MANAGEMENT SCIENCE AND COMPUTERS

The definition of Management Science activities proposed by Radnor, Rubenstein and Bean included the phrase "... who are involved in non-routine computer activities." Before this appreciation of Management Science can be completed it is important to examine this relationship with computers in more detail.

Operations Research was formally born in 1937 and the Operations Research Society of America was founded in 1953. The first large scale electronic computer was the ENIAC which was built in 1946 by the Moore School of Electrical Engineering of the University of Pennsylvania. The introduction of the first commercially orientated computers occurred in 1953 when the Sperry Rand Univac and the IBM 701 became available on a production line basis.

The time scale of the early history of the two innovations is very much the same. However it is reasonable to say that Management Science depended upon EDP far more than EDP needed OR/MS. The growth of the computer industry has been so spectacular that most OR/MS analysts must be employed in organisations that own or have access to a computer. Table 4 shows the increase in the number of computer installations internationally since 1956.

TABLE 4

NUMBER OF BUSINESS COMPUTER INSTALLATIONS[49]

Year	Number
1956	1 000
1961	10 000
1966	50 000
1971	100 000+ (US = 73 700 W. Europe = 24 000)
1980 (estimate)	200 000

What about the work going into getting the numbers for an OR/MS analysis?

In addition to greater availability, the increased power of computers has had a dramatic effect on potential OR/MS applications. Linear Programming was introduced in the early 1950's, the potential of the technique was immediately recognised but the computers then available were incapable of handling large LP problems. With each new generation of computers, newer and more powerful Linear Programming packages were introduced by the computer manufacturers.

The increased speed and greater capacity of computers has allowed OR/MS analysts to tackle more and more complex problems and to carry out more elaborate sensitivity analyses on their results. Although it would be wrong to define OR/MS as being entirely computer orientated it is worthwhile examining the second part of the working definition proposed by Radnor, Rubenstein and Bean at this stage: "... who are involved in non-routine computer systems activities".

There is no doubt that a great many of the recognised OR/MS techniques have limited practical application in the absence of computer assistance. As Table 3 indicated, Statistics, Simulation, Linear Programming, CPM/PERT, Inventory Theory account for over 70 per cent of the Operational Research applications performed in Japan, Great Britain, and South Africa. It is impossible to quantify when a management problem becomes unsolvable, if manipulation of the model has to be performed manually. However, the following quotations give some idea of the extent to which computers have been responsible for the development of OR/MS.

> Until we can solve these problems, there is little possibility of our running our economy, our businesses, or even individual factories with anything approaching optimum efficiency. Fortunately the last few years have seen enormous advances not only in the mathematical techniques available but also in the speed and power of the available computers, so that the realization of the dream of accurate economic prediction is almost within our grasp.[50]

> By the use of large computers and appropriate models it is now possible to treat a very much larger area of operations as one problem ...This is a significant step forward and represents an entirely new type of operating decision which could not possibly be made, on any worth-while scale, without the use of a computer and a 'decision-making' model.[51]

> Risk analysis, made practical by computers, has proven invaluable for evaluating alternative strategic plans with the help of simulation models, sometimes even including simulation of alternative competitive responses by the application of game theory. To exploit the potential of these and related techniques an increasing number of corporations find it necessary to supplement the professional skills of computer men by recruiting specialists in the Management Sciences.[52]

Mance (Ed) 1970

It is interesting to see that the final quotation refers to the recruitment of OR/MS activities to supplement the computer effort. This reinforces the belief of the inter-dependency of the one activity on the other. There are many more references in OR/MS literature which highlight this inter-dependence as well as the fact that the growth in the application of OR/MS techniques such as PERT, Linear Programming, and Simulation has been largely due to the improvements in computer hardware during the past ten years.

The "OR on OR" Group at Northwestern has evaluated the relationship between OR/MS activities and computers over the ten year period 1960-1970. Radnor and Neal in 1973, stated "The introduction of the third-generation computer was acknowledged as one of the most significant contributions to OR/MS by nearly all of the OR/MS practitioners participating in the study."[53] The most important advantages that were identified during the survey were:

(a) Adequate capability for large programs particularly LP

(b) Availability of time sharing facilities made it easier for the group to gain access to in-house installations

(c) Availability of time sharing facilities made it possible for groups to use outside computer facilities if relations with the in-house DP operations were unsatisfactory. (About 44 per cent of the sample of 108 OR/MS groups in major US companies were using this facility in 1970).

The availability of time sharing facilities has had a dramatic effect in educational environments internationally where third generation computers have proved particularly useful as a means of demonstrating the power of certain OR/MS techniques. An inventory package, for example, which is commercially available can be used in conjunction with a simulation sub-routine. The package updates stock status files for 1 000 items and generates orders for any items whose levels fall below the determined order points. This provides an extremely effective method of examining

the effects of management decisions on inventory levels. The programme runs on most commercial computers and will complete five simulations in ten minutes. It is impossible to do this manually as it takes about ten minutes to perform the calculation for one item.

It is therefore reasonable to conclude that there is an extremely important relationship between Management Science activities and electronic data processing.

CONCLUSION

In order to examine the results of American and International research on the diffusion of Management Science, it is first necessary to specify precisely what Management Science is and establish how it can be recognised in a business environment. Management Science activities may be located in functional areas under different organizational names, and in view of this a definition has been adopted which relates to techniques employed as this facilitates identification.

"A Management Science activity is one which performs work using the newer methods of mathematical analysis and/or is involved in non-routine computer systems activities."

As Operations Research itself is normally regarded as the use of rigorous sophisticated mathematical tools in problem solving, a modified name is proposed for the innovative activity.

Operations Research/Management Science (OR/MS) is a general term for all scientific business activities making use of Operations Research.

On the basis of this definition it is possible to recognise OR/MS activities in terms of the techniques they employ. The degree to which those techniques are encountered commercially varies significantly and the most commonly occurring are Statistics, Simulation, Linear Programming, CPM/PERT, Inventory Theory and Queueing Analysis.

The dependency on computers systems is stressed in the definition of OR/MS and in fact the power of most OR/MS techniques is due largely to the availability of computer support to provide solutions to problems involving complex analysis. Research has shown that advances in computer technology have had a significant effect on the progress and success of OR/MS.

REFERENCES

CHAPTER 2

1 F.W. Taylor, Scientific Management (New York: Harper Press, 1947)

2 Ibid., pp. 140-143

3 J.L. Riggs, Production Systems (New York: John Wiley & Sons, 1970), p. 445

4 F.B. Gilbreth and L.E. Gilbreth, Applied Motion Study (New York: The MacMillan Company, 1917)

5 H. Fayol, General and Industrial Management, translated by C. Stores (London: Pitman, 1963)

6 F.W. Lanchester, Aircraft in Warfare, Dawn of the Fourth Arm (London: Constable and Company, 1916), cited by P.M. Morse and G.E. Kimball, Methods of Operations Research (Cambridge, Mass: The MIT Press)

7 A.K. Erlang,"Solution of Some Problems in the Theory of Probabilities of Significance in Automatic Telephone Exchanges," The Post Office Electrical Engineers Journal, Vol. 10 1917-18, pp. 189-97, cited by L. Takacs, Introduction to the Theory of Queues (New York: Oxford University Press, 1962), p. 6

8 H.C. Levinson,"Experiences in Commercial Operations Research" Operations Research, Vol. I, 1953, pp. 220-239

9 J.F. McCleskey and F.N. Trefethen, Operations Research for Management (Baltimore: The John Hopkins Press, 1954)

10 Sir R. Watson-Watt, Three Steps to Victory (London: Odhams Press, 1964), p. 204

11 R.L. Ackoff and M.W. Sasieni, Fundamentals of Operations Research (New York: John Wiley and Sons, 1968), p. 5

12 J.F. McCleskey and F.N. Trefethen, op cit.

13 J.G. Crowther and R. Whiddington, Science at War (London: H.M. Stationery Office, 1948), cited by P.M. Morse and G.E. Kimball, Methods of Operations Research (Cambridge, Mass: The MIT Press)

14 R.L. Ackoff and M.W. Sasieni, op cit., p. 5

15 R.J. Thierauf and R.A. Grosse, Decision Making Through Operations Research (New York: John Wiley and Sons, 1970), p. 5

16 R.L. Ackoff and P. Rivett, A Manager's Guide to Operations Research (New York: John Wiley and Sons, 1963), p. 8

17 J.H. Engel, "Operations Research for the U.S. Navy Service World War II," Journal of the Operations Research Society of America, November-December 1960, p. 768

18 Data obtained from personal communication with the Secretaries of:
Operational Research Society (UK), 28th November 1974
Institute of Management Science (USA), 23rd September 1974

19 D.W. Miller and M.K. Starr, Executive Decisions and Operations Research (Englewood Cliffs, New Jersey: Prentice Hall, 1960) p. 3

20 P.M. Morse and G.E. Kimball, Methods of Operations Research, Massachusetts Institute of Technology: The Technology Press (New York: John Wiley and Sons, 1951), p. 1

21 R.J. Thierauf and R.A. Grosse, op cit., p. 13

22 G.L. Churchman, R.L. Ackoff and E.L. Ackoff, Introduction to Operations Research (New York: John Wiley and Sons, 1957), pp. 8-9

23 S. Beer, "Cybernetics and Operations Research," Operational Research Quarterly, Vol. 10, No. 1 (March 1959), pp. 16-17

24 R.L. Ackoff and M.W. Sasieni, op cit., p. 6

25 R.J. Thierauf and R.A. Grosse, op cit., p. 14

26 M. Radnor, A.H. Rubenstein and A.S. Bean, "Integration and Utilization of Management Science Activities in Organizations," Operations Research Quarterly, Vol. 19 (June 1968), p. 118

27 Northwestern University, Washington Operations Research Council, American Society of Public Administration. "Workshop on Management Science in the Federal Civilian Government," Fredericksburg, Virginia, December 8-11, 1968, cited by D.A. Tansik, "Several Hypothesised Influences of Organisational Goal Structures," p. 2. Paper delivered at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969

28 M. Radnor, A.H. Rubenstein and A.S. Bean, op cit., p. 118

29 R.L. Ackoff and P. Rivett, op cit.

30 S. Beer, Decision and Control (New York: John Wiley and Sons, 1966), p. 402

31 Ibid., p. 402

32 T.E. Caywood, "How Can We Improve Operations Research," Journal of the Operations Research Society of America, October 1971, p. 569

33 J. Dearden and V.L. Mote, "Operations Research at the Crossroads," European Business, October 1968, pp. 30-37

34 K.D. Tocher, "The Dilemmas of Operational Research," Operational Research Quarterly, Vol. 23, No. 2, p. 105

35 D.B. Hertz, "Has Management Science Reached a Dead End?" Innovation, No. 25, 1971

36 D.B. Hertz, New Power for Management (New York: McGraw-Hill, 1969)

37 H.M. Wagner, "The A.B.C.'s of OR," Journal of the Operations Research Society of America, October 1971, p. 1265

38 Ibid., p. 1266

39 J.D. Wiest, "Heuristic Programming for Decision-Making," Harvard Business Review, September/October 1966, p. 140

40 R.L. Karg and G.L. Thomson, "A Heuristic Approach to Solving the Travelling Salesman Problem," Management Science, January 1964, pp. 225-228

41 A.A. Kuehn and M.J. Hamburger, "A Heuristic Program for Locating Warehouses," Management Science, July 1963, pp. 643-666

42 P. Kotler, "Operations Research in Marketing," Harvard Business Review, January/February 1967, p. 44

43 E.H. Khoury and H.W. Nelson, "Simulation in Financial Planning," Management Services, March/April 1965, pp. 13-20

44 T.H. Naylor, J.L. Balintfy, and D.S. Bundick, Computer Simulation Techniques (New York: John Wiley and Sons, 1966), pp. 215-222

45 M. Radnor and R.D. Neal, "The Progress of Management Science Activities in Large U.S. Industrial Corporations," Journal of the Operations Research Society of America, March/April 1973, p. 434

46 J. Hough, R.J. Betts and S. Eilon, "Career Patterns of Operational Research Workers in the U.K.," Paper delivered at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969

47 T. Kawase, "Perspective on Management Sciences in Japan," Papers delivered at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969

48 E.S. Benikos et al, "Use of Operations Research in South African Commerce and Industry." Unpublished MBA Group Project, Graduate School of Business, University of Cape Town, Cape Town, December, 1970

49 K. Grindley and J. Humble, The Effective Computer (London: McGraw-Hill, 1973)

50 C.M. Berners-Lee (Ed.), Models for Decision (London: English Universities Press, 1965), p. vii

51 Ibid., p. 44

52 R. Mance (Ed.), The Arts of Management (London: McGraw-Hill, 1970), p. 350

53 M. Radnor and R.D. Neal, op cit., p. 443

C H A P T E R 3

TRENDS IN THE DEVELOPMENT OF OR/MS ACTIVITIES IN AMERICAN ORGANIZATIONS (1950-1970)

There have been fundamental changes in the leadership, location and methods of operation of OR/MS activities in America since 1950. These changes are important as they provide a means of identification of organizational factors which facilitate the diffusion and adoption of OR/MS. By examination of situations of discontinuance or rejection it is also possible to highlight those factors which adversely affect the diffusion process.

The factors that are discussed in this chapter include the following:

- the leadership of OR/MS activities
- the stability of organizational locations
- the changing attitudes of top management to OR/MS
- the need for formalization of OR/MS procedures
- the relationship between OR/MS and DP/MIS
- the influence of differing industrial sectors on the diffusion of OR/MS

In addition certain general problem areas are introduced which have been found to inhibit the diffusion process.

This chapter is based upon research carried out by the Northwestern Research Group who traced the history of OR/MS in 108 organizations in America between 1950 and 1970. The companies were large, 92 appeared in the 1970 Fortune listing of the Top 500 Corporations. Nearly all had experience of OR/MS and the majority had their own OR/MS groups.

The results of this research provide a unique record of the history of the first twenty years of OR/MS activity in American business. At the time of writing this is the most detailed and up-to-date record of the development of OR/MS.

OR/MS PERSONNEL

Certain changes have been observed in the type of individual working in and leading OR/MS activities. Research has shown that there are very definite reasons for this. The earlier Military leader-types were unique to the British and American environments for historical reasons. However the changes that have been subsequently observed clearly define the fundamental requirements for successful OR/MS group membership and leadership.

Types of OR/MS Personnel

Radnor, Rubenstein and Bean identified five different types of OR/MS personnel working in America in 1966.[1] The five categories were the following:

1. Military Types
2. Professional Scientists

3. OR/MS Specialists
4. Management Specialists
5. Organization Men

It is worth examining them in more detail to acquire a general classification of Operations Research/Management Science personnel.

1. Military Types

Generally scientists and mathematicians who were drawn into OR as a consequence of Military Operational Research activities. This Category consists of the "pioneers" who became involved during World War II (a small select group) and those who received their training in OR/MS in the military after the war.

2. Professional Scientists

This group is made up of scientists and mathematicians who were brought in to apply Operations Research techniques during the 1950's, from R and D, engineering and quality control. Although this group typically came into OR/MS during the period 1950-1960, recruits are still entering OR from the ranks of science and mathematics graduates in their first jobs.

3. OR/MS Specialists

These specialists have received specific training in Management Science prior to entering business. They generally are graduates in OR, Computer Science, Applied Mathematics, Statistics or Systems Analysis. These specialists started

entering industry in the early 1960's when the initial formal Operational Research and Industrial Engineering courses offered by American universities produced their first graduates.

4. Management Specialists

These people are products of more recent broadly based programmes in Industrial Management and Business Administration in which a significant proportion of curriculum is devoted to quantitative method and computers.

5. Organization Men

Generally production, marketing, or personnel men who have come up through the organization into OR/MS groups as a result of special skills. Often chosen to head up OR/MS activities to ensure practicability.

Four years later Radnor and Neal reappraised the situation and found that the classification still applied.[2] However, industrial engineers and business administration graduates with a higher proportion of OR electives were re-classified as OR/MS specialists.

Leadership of OR/MS Activities[3]

It was predicted that an increasing number of management specialists, OR/MS specialists, and organizational men would take over the leadership of OR/MS groups from Military and professional scientists. As Table 5 shows this forecast was essentially

correct except that the incidence of OR/MS specialist leaders reached a peak in 1964-1966 and had started to decrease by 1967-1970. Radnor and Neal believed that this was as a result of an increasing number of OR/MS required courses in Industrial Engineering and Master of Business Administration programmes, which produced an individual who was better suited to head up an OR/MS group.

T A B L E 5

INCIDENCE OF OR/MS LEADER TYPES IN MAJOR ACTIVITIES[4]

	At the end of Period				
	1950-55 %	1956-59 %	1960-63 %	1964-66 %	1967-70 %
Military	12	10	5	2	1
Professional Scientists	50	49	40	35	20
OR/MS Specialists	12	11	22	27	19
Management Specialists	-	-	7	8	21
Organization Men	26	30	26	28	39

At the completion of the survey Radnor and Neal depicted a "most desired" type of recruit for OR/MS - "an individual with an under-graduate background in engineering, some form of computer experience and an MBA."[5] This profile was based on the results of interviews with the group leaders who participated in the study. It indicates, as does the data contained in Table 5, that there is an increasing movement towards establishing an organizational

orientation within the OR/MS activity. This tendency contrasts with lack of organizational activity on the part of OR/MS groups that had been detected in previous surveys.

This change can be partially explained by the changed orientation of OR/MS work described in Chapter 2. The initial R and D/Engineering concentration of the activity has been replaced by a corporate organizational and financial preoccupation. This in turn has necessitated more of an organization orientation. Superimposed upon an educational grounding, the increasing use of sophisticated computer techniques introduces the final requirement in the "most desired" type description.

ORGANIZATIONAL LOCATION OF OR/MS GROUPS

One of the more important factors observed in America during 1950-1970 was the significant influence that organizational location can have on the stability of an OR/MS activity. This can be detected by analysing the organizational movements made by OR/MS groups during the period. The information appears in two papers published by the Northwestern Group in 1969 and 1973.[6,7]

The research group found that there was inherent instability in the location and activities of many of the OR/MS groups. As was discussed in Chapter 2, OR/MS groups' activities had shifted from R and D, Engineering, and Manufacturing to Finance, Data Processing and Management Planning.

The second study also showed that many of the changes in location and stability of OR/MS activities were in fact a reflection of underlying organizational changes. The earlier study had included Data Processing/Management Information Systems (DP/MIS) in the overall category of Top Management/Planning (TM/P). By 1970 many DP/MIS functions had emerged as separate entities each with its own vice-president. An equal number had been absorbed under a vice-president of Administrative services.

Many TM/P functions had been curtailed or abandoned. Radnor and Neal related this to the general instability of Long Range Planning activities, which are dependent upon the fortunes of individuals at top management levels. If the individual leaves, the activity loses its support and is subjected to antagonism from various levels in the organization. The role of the supporting individual or "sponsor" is extremely important in the case of OR/MS activities, and is discussed in more detail in the next chapter.

The second paper showed that the OR/MS groups located in TM/P had experienced the greatest change. Fourteen had been disbanded or moved to other areas of the organization, ten of them to DP/MIS. In six of the fourteen cases the change had been due to the departure of the original TM/P sponsor.

Analysis of the 21 OR/MS activities remaining in Top Management/Planning showed that ten had a more stable appearance than the remainder. These ten departments were more closely examined and it was found that the attitude of the sponsor was

particularly important in providing stability. Stability was dependent upon:

1. A co-operative relationship between the sponsor and his peers.

2. A willingness on the part of the sponsor to allow others to use the talents in his group.

3. A willingness on the part of the sponsor to allow free access to the group and not insist on having access to information exchanged.

4. A willingness to allow OR/MS activities developed in this way to establish themselves in other departments.

Stability was also found to increase if the OR/MS activity had unrestricted access to a computer facility.

The majority of sponsors were either still in control of their groups or in a higher position where they could exert influence to maintain the status of the group. The departure of the sponsor invariably meant that the future of the group would be affected.

Radnor and Bean found a general tendency for OR/MS activities to move toward DP/MIS departments. There were 108 groups in the programme. Fourteen of these had moved out of TM/P, ten of them relocating in MIS. Of the remaining 94 groups, 40 had relocated since their inception and 13 had moved to MIS locations. This is in keeping with the findings of Chapter 2

which indicated an increasing dependence upon computers. One of the advantages of a MIS location is the improved accessibility to the computer facility which itself increases stability. However an MIS location also provides a more stable position in the organisation as well as greater accessibility to data.

In summary the studies show that there are OR/MS group locations that are relatively unstable (such as R and D, Top Management/Planning) and those that seem to promise stability such as MIS. Conditions of instability occur when the function supporting the OR/MS activity is itself new or heavily dependent upon the support of a sponsor for survival. As the functions become established so the degree of instability will decrease.

TOP MANAGEMENT ACCEPTANCE

Another important change that has occurred in America since the early 1950's is a growing acceptance of the role that OR/MS can play in assisting top management decision-making.

"Research in this area during the period 1960-1970 has indicated that American managers are increasingly aware that OR/MS activities can bring about worthwhile improvements in their organisation."[8]

By 1970 54 per cent of the OR/MS supervisors indicated that their top managements were knowledgeable about and involved in their activities. This is significant as an earlier

survey carried out in 1964-1966 identified management support as being as low as 23 per cent. This may be due to the increasing number of managers in America who are aware of the potential of OR/MS and are willing to give support to Operations Research programmes. These managers may themselves have used OR/MS as a vehicle for achieving their success in the organization. Once in a position of power they are able to act as sponsors and to exert influence on the entire organization to accept and use Management Science techniques.

However there are other possible reasons for the increasing support for OR/MS activities such as:

1. the ever-increasing size and complexity of the business situation
2. the need for faster response times
3. the felt need to utilize fully the potential of the organization's computer facilities
4. the more complete and rapid exchange of information about new techniques
5. the need to answer the more sophisticated question currently being asked by customers, regulating agencies and stockholders.[9]

The entire question of top management support is linked to the attitude of top management towards change. This is discussed in more detail in Chapter 4.

Systems Analysis of this thesis.

THE RELATIONSHIP BETWEEN OR/MS AND DP/MIS

The five points in the previous section highlight the growing demand for the rapid solution of complex decision situations. In a situation in which an attempt is made to optimize the output from several related activities in a large organization the project often becomes highly complicated. The advantage of the OR/MS approach to problem solving is that it cuts across departmental boundaries in an attempt to capture the total situation. However without adequate DP/MIS backup to handle information collection, storage, retrieval and manipulation it is almost impossible for the OR/MS activity to make any significant progress. A harmonious working relationship is therefore essential if worthwhile results are to be achieved, and a significant interdependence of the two groups on one another is inevitable.

The dependence of OR/MS on computer accessibility has already been noted, and the tendency for OR/MS groups to find stability in DP/MIS locations was examined in a previous section. There is already a significant involvement of OR/MS groups in MIS activities.[10] Recent figures show 23 per cent of OR/MS activities heavily involved with MIS functions, and 50 per cent spending a large proportion of time working with and assisting the DP/MIS function. It is difficult to forecast the possible outcome of this involvement except to predict an extremely stable link being established between OR/MS and DP/MIS and rapidly increasing top-management awareness of the synergistic benefits resulting from the union.

THE EFFECT OF DIFFERING INDUSTRIAL SECTORS ON OR/MS ACTIVITIES

It would be anticipated that the environment of the organization would have a very marked effect on the development of OR/MS activities. Highly technical industries should be more responsible to the changes and attitudes involved in the development of formal OR/MS groups than industries which are less technically orientated. Research has shown that, in America, there appear to be relatively few significant differences which can be attributed to the type of industry or business involved. Some interesting relationships appear to exist.[11]

1. Capital Intensive industries, such as petroleum/chemical, tend to use OR/MS more than labour intensive organizations such as engineered products and merchandising.

2. The smaller the variety of inputs, processing steps, and outputs the greater the tendency to encourage the development of OR/MS.

It is not possible to acquire similar information for other countries but it is interesting to note that in a survey of members of the British O.R. Society, 17 per cent were drawn from the heavy mechanical engineering and metal industry; 15 per cent from chemical and allied industries; 8,5 per cent from food, drink, and tobacco; and 8,0 per cent from utilities such as gas, electricity and water.[12] This accounts for virtually 50 per cent of the members of the British Operational Research Society. Here the

conclusion unwarranted?

engineering orientation of the members is pronounced which is not in agreement with the situation in America. The very different origins of Operations Research in the U.S.A. and Britain obviously would have a significant effect on the development of OR/MS in the two countries.

Consequently it does not appear possible at this stage to forecast in which industrial sectors OR/MS activities are likely to be adopted most rapidly. Environmental factors seem to outweigh industry considerations in influencing the outcome of the diffusion process.

IMPLEMENTATION OF OR/MS RECOMMENDATIONS

One of the criteria that can be used to measure the increased acceptance of OR/MS is the extent to which recommendations are successfully implemented.

A certain amount of work has been done on the factors associated with the successful implementation of OR/MS findings. A 1968 paper produced by the Northwestern group stated that:

> Barriers to the implementation of results are critical to the success of projects and the program as a whole. No general methods have been found, so far, for assuring successful implementation. A number of methods have been used, ... They do not work under all conditions ... Among the methods reputedly used for bringing about successful implementation are these:
>
> 1. Assuring that there is a clear and recognised need for the results at the time the project is undertaken.

2. Involvement of the ultimate user of the results early in the process, and maintaining communication throughout the project.

3. Focus of the direction or strategy for the project in an individual or small group that can review progress and make decisions about changes in direction or level of effort.

4. Having top management support and enthusiasm.

5. Allowing or encouraging researchers to follow projects into application and make careers there, if they so desire.[13]

Although this list appears to be extremely sensible the authors caution that some of the methods have been used in projects which failed completely. They conclude that much more work will have to be done in this area before a reasonable theory of implementation is developed for OR/MS projects.

Radnor and Neal found that the percentage of companies experiencing implementation problems had decreased sharply from 25 per cent in 1964-66 to 12 per cent in 1967-70. In a subsequent paper[14] Radnor and Neal attempted to develop a relationship between the establishment of formal OR/MS procedures and OR/MS group success. The found that generally it was difficult to establish valid methods of measuring success. The proposed five measures of success, one of which was implementation - "the percentage of OR/MS projects completed and used."

They found that the decrease in the number of groups experiencing implementation problems could be mathematically associated with the degree to which formal procedures have been instituted. However as the authors point out this could in fact

be due to other factors such as increasing management involvement, older and more experienced OR/MS groups as well as the diffusion of OR/MS within the organization. However there does appear to be a reasonable positive correlation between formalization and implementation success.

FORMALIZATION OF OR/MS ACTIVITY[15,16]

The concept of "formalization" was introduced in the previous section and was broadly defined as the degree to which formal procedures for OR/MS activities have been instituted in an organization. A certain amount of research has been done relating to the measurement of the degree of formalization that exists in American companies, and the extent to which this has changed with time.

Formalization can be viewed in two lights. Firstly from the point of view of the formalization of communication or liaison procedures and secondly in terms of the operating procedures of the OR/MS group itself. Liaison can in fact be included in the list of formal operating procedures. It has attracted particular attention because of the importance attached to the relationships that exist between the OR/MS activity and the organization itself.

Formalization of Liaison Procedures

One of the changes observed during the period 1950-1970 was a marked increase in the degree to which OR/MS liaison procedures

had been formalized. Three basic principles were used to indicate the degree of formalization:[17]

(a) the establishment of a permanent OR/MS co-ordinating function;

(b) the establishment of a formal task force comprised of representatives from affected departments;

(c) the use of meetings and reports to monitor progress and costs and to institute corrective changes.

Table 6 shows the change in the degree of formalization over the period 1950 to 1970. The increase is readily apparent although here again conclusions are difficult to draw. It may be that as a group gets older, it inevitably finds that its activities and relationships with the organization become more formal.

T A B L E 6

FORMALIZATION OF LIAISON PROCEDURES BY PERIODS

	1950-55 %	1956-59 %	1960-63 %	1964-66 %	1967-70 %
% Activities employing a,b,c	11	14	22	50	80

Formalization of OR/MS Operating Procedures

The actual process of formalization has attracted many writers in OR and there are a number of articles which list the stages or procedural steps required to formalize OR/MS activities. Radnor and Neal presented a matrix based upon the recommendations of ten writers which listed 20 steps ranging from "preliminary analysis" to the final "update and maintain!"

The main criticism of the majority of these papers is that they tend to ignore the problems associated with the selection of OR/MS projects. Most procedural programmes start from the point in time when the project has already been selected. Radnor and Neal believe that the process of project selection is the most critical aspect of the formalization process and yet only one author has gone into any detail on the subject.[18] Ideally projects should be selected so as to:

1. build organizational confidence in the group, based on projects with a high probability of success;
2. establish a solid relevant need for OR/MS techniques based on a varied mix of projects that involve a relatively wide multilevel cross section of the organization;
3. ensure a logical and efficient ordering of projects so that they would build into one another and the results of the previous programmes would not be obliterated by those immediately following.

There are several common areas in most of the papers on formalization. Radnor and Neal presented an idealised specification of procedural steps drawn from the matrix. The list is shown in detail in Appendix A and is subdivided into seven phases -

1. Preliminary Selection - project proposal phase
2. Justification - project initiating phase
3. Final Selection - project approval phase
4. Project development phase
5. Project review phase
6. Project implementation phase
7. Project routinization phase.

The list was then condensed to give eleven procedural levels and used as a check to determine the degree of formalization in 104 companies. It was found that the degree to which any of these procedures were used varied considerably from company to company (Table 7).

T A B L E 7

FREQUENCY OF USE OF PROCEDURAL ELABORATION CRITERIA

Criteria	Frequency of Use (%)
1. Formal Selection Committee	34
2. Long-Range Planning	44
3. Formal Initiation Request	50
4. Cost Benefit Analysis	59
5. Task Force	32
6. Permanent Liaison	32
7. Schedule of Events	76
8. Schedule of Resources	74
9. Monitor Progress	73
10. Formal Post Audit	32
11. Reports/Documentation	62

It was found that the median number of procedures used by a company was 6 (mean 5,76), which shows that most companies do employ some type of plan for the implementation of OR/MS activities. The most commonly used procedural levels are:

- Scheduling of Events
- Scheduling of Resources
- Monitoring of Progress
- Reporting and Documentation

which indicates that most organizations are more concerned with the control of projects than their selection.

A disturbing feature of the data in Table 7 is the fact that about two-thirds of the 104 companies do not find it necessary to set up formal committees for the selection of OR/MS projects, or to establish permanent liaison channels, or carry out post-audits on OR/MS projects. The possible explanation is interesting. Research has shown that the older, better established OR/MS groups pursue their activities more informally than the newer groups because of the working relationships that have been established with the rest of the company.[19]

PROBLEMS FACING OR/MS GROUPS[20]

Communication

One of the main problems that has faced OR/MS groups since their introduction into industry in the 1950's is the communications gap that exists between OR/MS personnel and the remainder of the organization. This problem is not unique to Operations Research and initially all activities appearing under the Management Science label suffer the same situation. Very similar problems exist in DP/MIS and generally all these stem from the "inability of their group to communicate concepts in terms that could be understood by their respective organizations."

These problems appear to be decreasing with time. Surveys carried out in American OR/MS groups show that the percentage of time devoted to "educating" management is decreasing. There is probably a direct correlation between this and the increase in management support detected between 1960 and 1970. The rapid growth in the number of university trained management specialists during the ten year period has meant an increasing awareness of the potential of OR/MS activities, furthermore the success of the work done by OR/MS groups has created a more favourable environment for the education of middle management.

Decentralization

A further problem has been due to the tendency to create decentralized profit centers in American organizations whilst retaining a centralized management information and control function at ~~corporate level.~~ The resulting political and strategic problems have increased the instability of OR/MS activities and have at the same time made the communications problems more serious.

General

Other problems which still cause OR/MS groups difficulty from time to time are:

1. Lack of data standardization across divisions
2. Difficulties in identifying sources of raw data
3. Inadequate facilities for capturing and transmitting data
4. Protection of vested interests
5. Subjective local views leading to sub-optimization

6. OR/MS group unable to control the direction and outcome of its effort.

The first three items relate specifically to DP/MIS problems and once again highlight the benefits which accrue to an OR/MS activity located within a DP/MIS department. The last three items could be predicted from the nature of OR/MS activities which generally bring about significant organizational change.

CONCLUSION

In order to identify the key factors that may influence the diffusion of OR/MS activities in South African business, it is useful to examine the history of the development of OR/MS in America during the period 1950-1970. Certain fundamental changes have been observed which highlight some of the important historical trends that have influenced the diffusion process. The trends reviewed in this chapter were the following:

(a) Top management support for OR/MS activities in America increased significantly between 1950-1970, as managers became more aware of the potential uses of OR/MS. This change can be ascribed to the emergence of a new generation of trained management specialists, the increasingly competitive demands made on the resources of organizations, and the demonstrated ability of OR/MS techniques to provide a solution in complex decision situations.

(b) There has been a definite movement of OR/MS activities into DP/MIS functions. Certain functions such as R and D and Top Management/Planning do not appear to provide stable organizational locations for OR/MS, whilst others, such as DP/MIS, appear to promise stability. It has been established that OR/MS activities become more stable if they have easy access to computer support and this factor, together with the inherent stability of DP/MIS, makes this a natural location for OR/MS.

(c) OR/MS groups are staffed by a variety of different types of individual - professional scientists, military OR/MS personnel, OR/MS specialists, management specialists, and organizational men. Although it was anticipated that OR/MS specialists would become increasingly important in this environment, this has not been the case. The "most desired type" is not the highly quantitative OR/MS graduate. Organizational men with DP/MIS experience and management specialists appear to make the best leaders of OR/MS activities. The type of recruit best suited for OR/MS is defined as "an individual with an undergraduate background in engineering, some form of computer experience and an MBA".

This change has been primarily due to the changed orientation of OR/MS which has moved away from R and D/Engineering and now has a financial and corporate/organizational preoccupation. The magnitude and complexity of projects being tackled impose a significant computer modelling and systems requirement.

(d) OR/MS activities rely heavily on the support of a "sponsor" particularly when located in an unstable functional area such as Long Range Planning. The "sponsor" is generally a senior executive in the organization who is favourably disposed towards OR/MS. The role of the sponsor is important and many disintegrations of OR/MS activities can be attributed directly to the departure of the sponsor.

(e) No clear indication of industrial preference for OR/MS activity has yet emerged. It appears that historic and environmental considerations currently play a more important role.

(f) The problems associated with the implementation of OR/MS findings have been found to decrease as the formalization of OR/MS activities increases. During the last ten years there has been a marked increase in the number of OR/MS groups which employ formal liaison procedures within the organization. Most groups have instituted formal procedures for the control of OR/MS projects but the selection of projects does not seem to have reached the same level of formalization.

(g) Certain problems remain which tend to hamper the diffusion of OR/MS activities. There is still a communications barrier between OR/MS practitioners and people in the organization. Decentralization of profit centres causes problems when an OR/MS project seeks to optimize the total system. Data

collection and data processing cause major difficulties, whilst the normal resistance to change is still encountered.

In conclusion, it can be said that OR/MS activities have been generally adopted by most of the larger American companies. The diffusion process has been expedited by increasing pressures and the complexity of decisions that are encountered in the American business environment. The causes of many of the earlier rejections and discontinuations have been identified. These include the unsuitability of highly quantitative OR/MS specialists as leaders and members of OR/MS activities. As a result it has been possible to redefine the "most desired" type of OR/MS recruit, and to relocate OR/MS activities in functions such as MIS rather than Long Range Planning.

Research has shown that OR/MS activities are likely to be adopted if they have free access to computer support as this enables them to perform their functions more successfully. An extremely strong bond exists between DP/MIS and OR/MS which is likely to develop even more in the future.

The role of the sponsor or change agent has been found to be important in ensuring the adoption of an OR/MS group. However in an unstable location such as Long Range Planning, discontinuance generally occurs if the sponsor leaves the organization. In many cases the group ceases to exist or moves to a DP/MIS location.

REFERENCES

CHAPTER 3

1 M. Radnor, A.H. Rubenstein, and A.S. Bean, "Integration and Utilization of Management Science Activities in Organization," Operations Research Quarterly, Vol. 19 (June 1968), pp. 117-141

2 M. Radnor, and R.D. Neal, "The Progress of Management Science Activities in Large US Industrial Corporations," Journal of Operations Research Society of America, Vol. 21, No. 2 (1973), pp. 427-450

3 M. Radnor, A.H. Rubenstein, and A.S. Bean, op cit., p. 121

4 M. Radnor, and R.D. Neal, op cit., p. 431

5 Ibid., p. 432

6 M. Radnor, A.H. Rubenstein, and A.S. Bean, op cit.

7 M. Radnor, and R.D. Neal, op cit.

8 Ibid., p. 449

9 Ibid., p. 445

10 Ibid., p. 444

11 Ibid., p. 447

12 J. Hough, R.J. Betts, and S. Eilon, "Career Patterns of Operational Research Workers in the UK," paper delivered at the XVI International Meeting of the Institute of Management Sciences, New York, March 1969

13 M. Radnor, A.H. Rubenstein, and D.A. Tansik, "Implementation in Operations Research and R and D: In Government and Business Organizations," paper presented at the 34th National Meeting of ORSA, Philadelphia, Pa., November 6, 1968

14 R.D. Neal, and M. Radnor, "The Relation between Formal Procedures for Pursuing OR/MS Activities and OR/MS Group Success," Journal of the Operations Research Society of America, March-April 1973, pp. 451-474

15 M. Radnor, and R.D. Neal, op cit.

16 R.D. Neal, and M. Radnor, op cit.

17 M. Radnor, and R.D. Neal, op cit., p. 439

18 D.G. Malcolm, "On the Need for Improvement in Implementation of OR," Management Science, 11 B54-B57 (1965)

19 M. Radnor, and R.D. Neal, op cit., p. 440

20 Ibid., p. 441

APPENDIX A

FORMAL PROCEDURES IN PROJECT SELECTION

1. Project-proposal phase (preliminary selection).

   (a) Development of intermediate and long-range plans with associated problems and needs.

   (b) Listing of relevant OR/MS projects.

   (c) Preliminary rating of projects in terms of risk, need, and timing.

   (d) Preliminary selection of OR/MS projects.

2. Project-initiating phase (formalization of initiating requests, justification).

   (a) Problem formulated in terms of objectives and criteria for measuring the accomplishment of objectives.

   (b) Feasibility considered in terms of technical, operational, and behavioural factors.

   (c) Cost/benefit analysis with respect to the overall organization.

      (1) Development costs - one shot.

      (2) Operation costs - repetitive.

      (3) Benefits.

3. Project-approval phase (final selection).

   (a) Review of project requests by committee of concerned individuals, such as OR/MS practitioners, potential clients, and representatives of other staff functions.

   (b) Resolve conflicts, negotiate priorities, work out project schedules.

   (c) Make recommendations to top management.

   (d) Obtain top-management approval.

4. Project-development phase.

   (a) Plan/schedule events (including review points) and resources.

   (b) Establish a project team that includes the ultimate users.

      (1) Establish responsibilities.

      (2) Establish lines of communication.

   (c) Collect data.

   (d) Develop model/solution (may have more than one).

   (e) Test model/solution (with hypothetical or actual data).

   (f) Evaluate test results and modify as necessary.

5. Project-review phase.

   (a) Review results in accordance with expectations (describe unforeseen difficulties, costs, gains).

   (b) Make recommendations.

   (c) Obtain top-management approval.

6. Project implementation phase.

   (a) Project indoctrination.

   (b) Schedule events (including review points) and resources.

   (c) Prepare user manual (outline control mechanics).

   (d) Train personnel.

   (e) Monitor progress and correct problems that occur.

7. Project routinization phase

   (a) Evaluate project to determine degree of success, problems, improvements, and future extensions.

   (b) Write final report and circulate as desirable.

CHAPTER 4

THE LIFE CYCLE OF OR/MS ACTIVITIES

The previous two chapters examined the origin and development of Management Science activity. It is now necessary to discuss the Diffusion process through which OR/MS activities first appear in a business and subsequently establish themselves in the organization structure.

This chapter is devoted to an analysis of the "Life Cycle" of OR/MS activities. This consists of a series of phases - Pre-birth, Introductory, Transitional, Maturity - which are similar to the phases of the Innovation Diffusion process as a result of Authority-Innovation Decisions. The final phase of the Life Cycle, Death, corresponds to Rejection or Discontinuance depending upon when it occurs in the Life Cycle.

The reasons for the rejection or discontinuation of OR/MS activities are discussed. In particular the problems associated with the implementation of OR/MS recommendations, and the attitudes of OR/MS specialists are examined. The role of the Sponsor or Change Agent, which has been found to be critical in the early stages of the Life Cycle, is analysed in some detail. The critical relationships which affect the OR/MS group within the organization are presented as these can also affect the success of the group.

The last portion of this chapter deals with the concept of success. The speed with which an OR/MS activity passes through the phases of the Life Cycle to Maturity is very much dependent upon the Effectiveness or Success of the activity. Success appears to be influenced by a variety of different factors which are briefly examined. Finally the impact of Success or Failure on the group as it passes through the Life Cycle is discussed. This is an important aspect as it must influence the nature of projects selected by OR/MS groups at various stages of the Life Cycle.

THE LIFE CYCLE OF AN OR/MS GROUP[1]

Although it was apparent as early as 1960 that Management Science activity was growing in American companies, it also appeared that many of the OR/MS groups so formed had a short life and were either dissolved or transferred between various organizational functions. The Research Group at Northwestern attempted to describe the events which occurred during "the history of an OR/MS activity (and) the conditions under which it functions, and (influences its) effectiveness".[2] In order to examine this history more closely the Group proposed "A Life Cycle" of the growth and decay of OR/MS activities. There are five phases in the Life Cycle and they are defined as follows:[3]

1. Pre-Birth Phase

   Some people in the organization are expressing ideas on the possibilities of having OR/MS activities. No formal activity exists and no resources are officially devoted to such work. However, some informal OR/MS type of project may be occurring.

2. Introductory Phase

   Management has granted a "charter" to perform OR/MS work. This is temporary and may be specific to a project or programme. The organization is trying something new, using OR/MS ideas and techniques. Resources have been officially allocated for such activities.

3. Transitional Phase

Management has a longer term commitment to OR/MS activities. These may be performed either in a group or in diffused form (i.e., by individuals in different parts of the organization). Management has indicated the intention of using OR/MS in the decision-making processes of the organization. While OR/MS is not yet taken for granted as a permanent organization activity there is no time limit on its charter.

4. Maturity Phase

Management has accepted the OR/MS group functions as a permanent part of the organization. The time horizon for the commitment of resources and the acceptance of OR/MS as an essential part of the decision-making process approaches infinity. Again the activity may be carried on in a group or in diffused forms.

5. Death

The complete discontinuance of an on-going activity or the return to either Phase 1 or Phase 2.

The Life Cycle phases do not necessarily have to follow one another in numerical sequence. It is possible, for example, for a group to move from the Pre-Birth Phase to the Introductory Phase; and subsequently, due to a failure to achieve desired results directly to the Death Phase. The phases reflect the organization's commitment to the OR/MS activity. Organizational commitment is in fact defined in terms of management or user

attitude towards the activity, and attitudes can change as a result of bad reports from a user.

The Life Cycle is affected by certain organizational conditions or situations. The degree to which the Life Cycle is affected varies significantly depending upon the phase of the Life Cycle that a group has achieved within the organization. For example the effect of an unsuccessful project would be far more dangerous to an OR/MS group which is still in the Introductory or Transitional Phases than it would be for a group that has firmly established itself in the organization. This is discussed in more detail later in this chapter.

The Pre-Birth and Introductory Phases of the Life Cycle are probably the most critical ones. The introduction of Management Science activity into an organization is the first stage of the innovation-diffusion process - there is an "awareness" of OR/MS.

THE PRE-BIRTH AND INTRODUCTORY PHASES

The Introduction of OR/MS Activities

The factors which are likely to bring about the introduction of OR/MS activity have been identified. These factors reinforce each other and consequently if more than one of the factors exist the likelihood that an OR/MS activity will be established increases. There appear to be two principal ways in which OR/MS groups are created.[4]

1. Internal Evolutionary Process

OR/MS skills are built up in some part of the organization, usually when employees are recruited who have OR/MS experience. This often happens in staff functions such as R and D. Over time greater and greater use is made of certain Operations Research techniques until there is enough internal support to create a formal OR/MS activity.

2. Externally Induced Process

In this instance a person with power and influence within the organization, who is aware of the potential of OR/MS, recognises possible areas of application for Operations Research. This person is usually referred to as the "sponsor" or change agent. As a result of the influence of the sponsor, a formal OR/MS group is established within the organization. It has been found that this type of sponsorship generally results in the formation of groups which have a substantial initial charter. The OR/MS leader is often authorized to hire a number of OR/MS professionals to develop the kind of team he believes is necessary to do OR/MS work.

The factors which appear to reinforce one another and lead to the establishment of an OR/MS activity by means of an Internal Evolutionary process are shown in Figure 1.

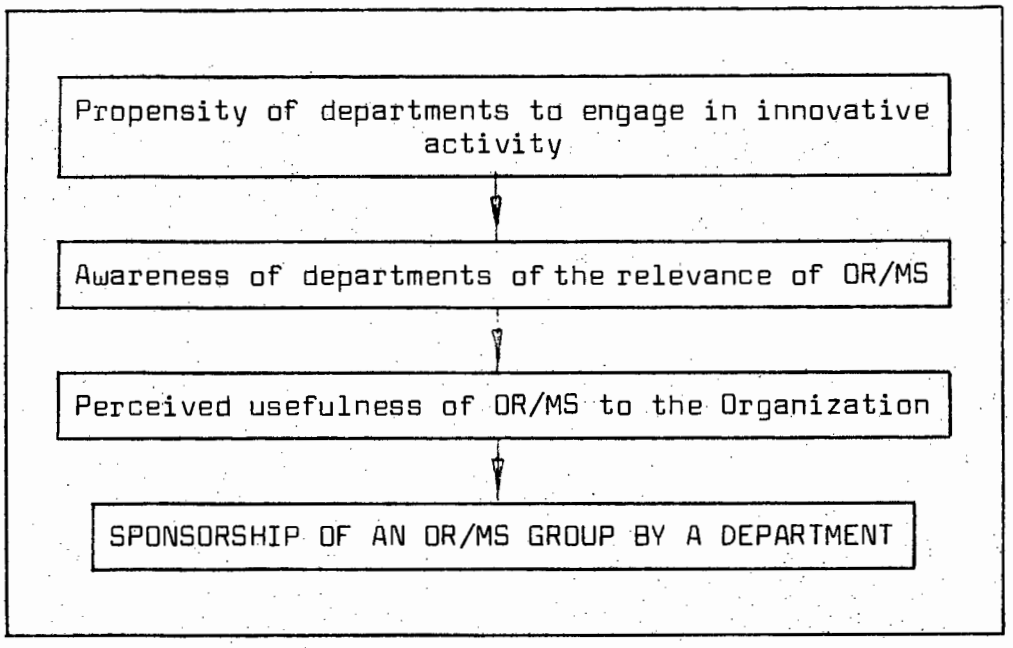


Figure 1

Factors Influencing the Establishment of an OR/MS group by an Internal Evolutionary Process[5]

The paradigm shows that the greater the tendency of departments to indulge in innovative activities, and the greater the awareness of the relevance of OR/MS the greater the likelihood that an OR/MS activity will be established as a result of sponsorship by a Department.

The factors which support one another and lead to the establishment of an OR/MS activity by an Externally Induced Process are shown in Figure 2.

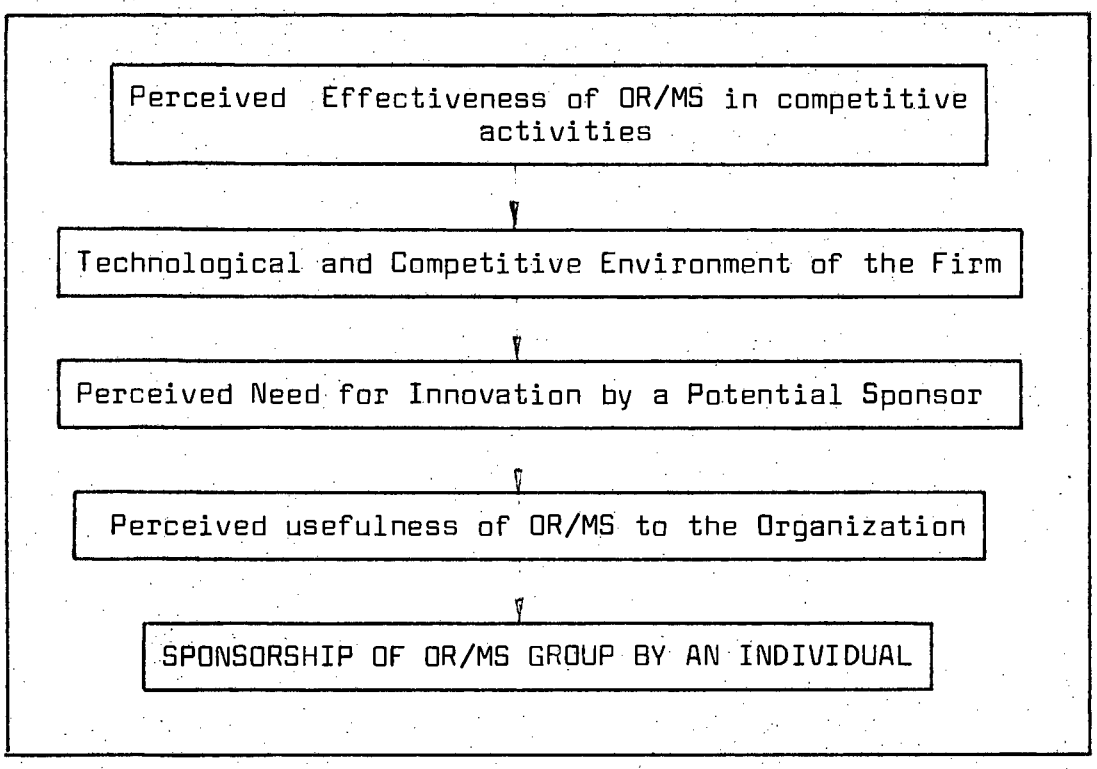


Figure 2

Factors Influencing the Establishment of an OR/MS group as a result of an Externally Induced Process[6]

As the paradigm shows several factors reinforce one another here as well. For example, a sponsor is more likely to become aware of the effectiveness of OR/MS techniques if they are used by competitive organizations or if the environment of the firm is such that OR/MS activities have been found to be particularly useful. This would apply to the use of Linear Programming in Petroleum Refining.

There are obviously cross relationships between the two processes at all stages. The sponsor is likely to find that his idea of introducing an OR/MS group will be more favourably received if there are departments in the organization - such as R and D - which favour the use of new techniques. Alternatively an OR/MS group is more likely to be established as a result of Internal Evolutionary Process if a staff department using OR/MS techniques is able to convince a potential sponsor of the need for a formal OR/MS activity.

The Task of the Change Agent in the Pre-Birth and Introductory Phases

The role of the Change Agent or Sponsor in Innovation-Diffusion situations in extremely important and has been discussed in some detail in previous chapters. In social systems generally it has been found that change agents are likely to be more successful if they adopt a participative attitude towards their clients rather than an authoritative one, even in Authority-Decision situations. This is confirmed by the fact that successful OR/MS sponsors appear to allow their OR/MS groups great freedom of movement and permit unrestricted access by the rest of the organization.

Bean has found that the role of the sponsor is critical during the Introductory period in the OR/MS Life Cycle. The chances of a member of top management deciding to adopt a group (Externally Induced Process) are very much dependent upon the attitudes and environment of the individual concerned.

Sponsorship is positively related to:[7]

- the career aspirations of the manager
- the manager's formal exposure to OR/MS
- the manager's orientations
- the organizational security of the manager
- the pressures exerted on the manager by his peers
- the size of the organization
- the growth rate of the organization
- the technology of the organization

Once an individual has decided to sponsor an OR/MS activity, the sponsorship may be provided in a variety of ways.[8] The sponsor may be a client of the OR/MS group and thereby ensure the continued existence and stability of the group. Alternatively, the sponsor may suggest projects to other clients in the organization or may initiate projects for the OR/MS group to work on. As the definition of the Externally Induced Process stated, the sponsor may also secure material resources for the OR/MS group. These activities will take the group from the Pre-Birth Phase and the Introductory Phase of the Life Cycle to the Maturity Phase.

THE RESISTANCE TO FORMAL OR/MS ACTIVITY IN THE INTRODUCTORY AND TRANSITIONAL STAGES OF THE LIFE CYCLE

Earlier in this chapter it was noted that an ongoing OR/MS group could be disbanded at any stage of the Life Cycle and OR/MS activity within the organization would return to the Pre-Birth Phase. An instance of this was demonstrated in Chapter 3

when the instability of certain organizational locations was examined. OR/MS groups located in Top Management/Planning continued to exist only as long as their sponsors remained in a position of power where they could influence the activities of the group. It was found that the departure of the sponsor led to the disintegration or relocation of the OR/MS group.

It is important at this stage to understand the problems that confront an OR/MS group in the Introductory, Transitional or even Maturity phases of the Life Cycle. At all times it must be remembered that OR/MS groups require clients in order to survive. Clients can approach the group of their own free will or under pressure from the sponsor. This is one of the basic problems with Authority-Innovation Decisions; although management has decided to create a formal OR/MS activity, it is up to individuals in the organization to decide whether or not they will actually adopt the activity and use it effectively.

It has been found in practice that many Authority-Innovation Decisions lead to situations of Innovation Dissonance. This is defined as the difference between an individual's attitude towards an innovation and the attitude demanded by the decision unit. The adoption unit complies with the requirements of the decision unit so as to maintain a favourable relationship with the decision unit. However, compliance is generally temporary and must be supervised to continue.[9]

As a result individual departments may continue to employ the OR/MS group until the sponsor leaves the company. Alternatively departments may appear to use the services of the group, but will ensure that the projects assigned to the group are trifling or impossible to solve.

It would appear that OR/MS activities are subject to an exceptional degree of resistance within the organization. The reasons for this resistance must be understood before the particular difficulties associated with the diffusion of OR/MS can be fully appreciated.

Organizational Change and OR/MS Activity

The introduction of a Management Science activity into an organization inevitably results in organizational change of some sort. It will be recalled that the majority of definitions of Operations Research referred to the "use of scientific techniques to optimize the performance of the total organization". As a result OR/MS recommendations which are accepted and implemented may affect the operation of the entire organization.

An organization is a Complex of people, resources and work; all linked to each other by a network of systems.[10,11] Any work done by the OR/MS group which is designed to optimize the performance of some aspect of the organization will bring about changes throughout the Complex. This is in line with a definition of a Change Agent as a person "whose job is to help a system in a process of deliberate planned change in its own internal processes or in its

relationships to the outside world".[12] A successful Change Agent hopefully achieves desired results by a seven stage process which includes establishing the desire to change, initiating the change, and subsequently stabilising the change.[13]

The activity of an OR/MS group is aimed at improving the overall operating effectiveness of an organization. The charter of most groups does not recognise organizational and departmental boundaries. As a result, a group may present recommendations which significantly affect the entire organizational structure. These changes will be resented by traditional managers in the organization. Grant has painted a stark picture of the situation that may arise.

> Because Management Scientists are "Change Agents" and because their work is likely to disturb long-established methods and procedures, inevitably they cause conflict and hostility in people exposed to their innovations. The role of Management Scientists will always be a stressful one as most organizations contain considerable built-in resistance to change. Often Management Scientists are at loggerheads with some of the most powerful men in the organization, many of whom are ambivalent to change.[14]

OR/MS Groups Under Stress

The task of the OR/MS group leader is an onerous one, particularly if the group is fairly new or is in the process of being established. Bean has commented that the manager's job involves "problems in the management of change as well as the problems in the management of a professional problem solving group".[15] This situation taxes the resources of the best managers.

Research studies have shown that both OR/MS leaders and OR/MS personnel are adversely affected when they encounter antagonism within the organization. Under stress they begin to act defensively which does not improve the feelings of the organization towards them. A typical case study of an OR/MS situation describes the outcome of such a confrontation.

Argyris studied an OR/MS group operating in a large corporation.[16] The team contained about 20 professionally trained members and was headed by a mathematical statistician who had been promoting quantitative management techniques to top management for some time. The company used fairly unsophisticated financial analysis techniques to manage the business. The OR/MS group regarded these techniques as obsolete but were unable to put forward sufficiently strong reasons for changing them. These feelings were not openly expressed but as a result meetings of the OR/MS group with top management tended to be tense because the group had to try to convince management of the need to adopt improvements without actually deriding established practice. Under stress the OR/MS group

> loses some of its composure, it produces more behaviour scored as conformity and antagonism, it suppresses its feelings of tension by intellectualizing them; it does little to help its own members or others to become more open, to explore new issues, and to take risks.[17]

The OR/MS group was aware of the situation that had developed but tried to explain it away in terms of their own feelings:

> The biggest single difficulty lay in commucating with and convincing 'user' departments, that a change or series of changes was, in fact, in their and the company's interests.[18]

Argyris then reports the reaction of the management team towards the OR/MS group. They experienced feelings of mistrust, suspicion, and inadequacy. These feelings were not conveyed openly, but as a result the OR/MS group found it impossible to obtain suitable clients in the organization. Projects that were forthcoming were either ridiculous or alternatively impossible. In the former case these projects ensured that the status of the group remained low within the organization. In the latter case, it was impossible for the group to study the problem in detail and produce worthwhile recommendations. Both types of project increased the tension and frustration felt by the group.[19]

Once an OR/MS group establishes this type of relationship with the remainder of the organization it is only a matter of time before it ceases to exist. If the group is being sponsored by a member of senior management it will remain operational only as long as the sponsorship lasts.

This case study serves to illustrate the manner in which an OR/MS group, apparently in the Introductory or Transitional Phases of the Life Cycle, can find itself in the Death Phase. It is clear from the case study that resistance to OR/MS activities may arise as a direct result of the attitudes and values of the members of the OR/MS group.

The OR/MS Mentality

Why is it that OR/MS personnel tend to annoy the very people that they are trying to assist? Why is it that OR/MS activities are viewed with suspicion by other members of an organization? Part of the reason lies in the far reaching changes classically associated with OR/MS activity, and part lies in the typical nature of OR/MS personnel. The latter aspect was briefly explored in Chapter 3 when the changing nature of OR/MS leadership was examined. It was found that OR/MS specialists were not ideally suited for OR/MS activities. Individuals with a technical background in management or individuals who had several years of experience within the organization appeared to be better suited to work in and lead OR/MS groups. Research has shown that unless OR/MS personnel have an organizational orientation they are unaware of the problems they may cause.

It was so stated, but not proved.

As a result of their training and backgrounds many OR/MS practitioners are unable to see the grey areas in management and decisions can only be black or white. Their attitude towards managers becomes increasingly aggressive. They identify themselves as missionaries whose duty it is to educate managers in a more rigorous and scientific approach to their jobs. This education takes on the form of coercion - "to force people to become more explicit in their thinking in order to be more effective".[20]

Once again Grant has best expressed the limitations of the OR/MS mentality:

> Few management scientists appreciate the fundamental nature of their roles and the tremendous social impact of their new techniques on organizations. Nor do many understand the very real fears of people on the receiving end of change i.e. those who see themselves as change victims. Because of this, management scientists pay little attention to establishing good interpersonal relationships with their clients. They tend to look upon their clients who object as being obstructive or stupid.[21]

The attitudes and behaviour of the management scientists are obviously of paramount importance when a group is introduced to an organization. Although the basic theory relating to the introduction of a group of sophisticated technical experts into an established organization structure is underdeveloped it is very much linked to various aspects of organization theory.[22]

One of the basic problems is that the OR/MS group and the "user" or "client" group are in fact in competition with each other, unless the introduction of the OR/MS group has been achieved in such a way that the user group has requested assistance. The subsequent behaviour of the two groups can be predicted by examining the dynamics involved in competitive group behaviour.

1. Each group begins to see the other as an enemy.
2. Each group begins to experience distortions of perception.
3. Hostility towards the other group increases while interaction and communication with the other group decreases.
4. If the groups are forced into interaction ... each group is likely to listen more closely to their own representatives and not listen to the representative of the other group, except to find fault with his presentation ...[23]

The Changes in OR/MS Orientation

The previous sections have dealt with some of the problems faced by OR/MS activity during the various phases of the Life Cycle. For these and a number of other causes groups have been relocated, disbanded, or have been allowed to disintegrate. However, these problems have been observed by research groups over the last ten years and steps have been taken by many OR/MS groups to reduce the likelihood of Death. It is worthwhile briefly restating the problems before looking at the changes that have occurred within OR/MS.

The normal problems of organizational change are acute in the case of the introduction of OR/MS activities in an organization. The type of projects which most OR/MS analysts find particularly interesting are those which pose the greatest threat to members of the established organization as they tend to be associated with dramatic and far reaching organizational change. The individuals who are classically involved in OR/MS are generally least likely to appreciate the feelings of fear and apprehension that they cause amongst prospective clients. As they are unaware of these deep-rooted anxieties they are unable to understand why their attempts to find "clients" or attack fundamental problems are rejected or delayed. This causes aggression and frustration in the OR/MS group which increases the tension that exists between them and their would-be organizational clients. The two groups tend to become more and more hostile and standard reactions associated with intergroup conflict develop.

Clearly the foregoing comment relates to the classical problems that are associated with the introduction and diffusion of OR/MS activities. Initially these problems must have been acute and the clash between "military" operational researchers and non-technical management in the 1950's must have developed along the lines previously discussed. In the interim two fundamental changes have occurred.

- Companies have realized the importance of OR/MS and there has been a gradual acceptance of the inevitability of a change to more quantitative management techniques.

- The orientation and personnel of OR/MS activities themselves have changed.

The changes observed in OR/MS orientation between 1950 and 1970 were discussed in some detail in Chapter 3. In the light of the foregoing comment it is worthwhile to re-examine these changes to find the underlying explanations.

1. There has been a marked change in the type of person deemed most desirable for OR/MS activities. The decline of "military" and "OR/MS specialists" has been accompanied by an increase in the proportion of individuals with a background in general management and organizational experience. This was an unexpected development, as initially an increase in the number of OR/MS specialists had been forecast. It was also found that a DP/MIS background was extremely important.

It is likely that having had experience of the problems of change associated with the introduction of computers and having successfully overcome these problems, this type of person would be ideally equipped to work in or head up an OR/MS activity. This trend confirms that organizationals are less likely to experience or cause those problems specifically associated with OR/MS specialists with highly quantitative backgrounds.

2. OR/MS groups have tended to move from Engineering/R and D departments to Administration and Finance. Although it is not possible to confirm this, it is likely that initially it was easier to locate groups in technically orientated departments where the clash between OR analyst and manager would be lessened due to a greater probability of mutual understanding. Once the group was established and had gained a reputation for successful work, the transition to other areas of the organization would be less traumatic.

3. During the 1960-1970 period there was a marked movement of OR/MS groups into DP/MIS locations. This trend could be explained by the mutual dependance of two innovations upon each other. This would result in a feeling of trust and solidarity, particularly as many OR/MS analysts have similar backgrounds and attitudes to systems analysts and data processing managers.

4. OR/MS groups were often found to owe their existence to a sponsor, an individual in top management who supported the group and promoted its activity. Once this individual left the company or moved to another division the group tended to disintegrate. These groups may have relied entirely upon pressure exerted by sponsor to obtain clients and implement recommendations. Although the projects carried out by the groups may have been successful, it is likely that user departments resented the pressure applied from above. Once the pressure ceased the group would be subject to greater than normal hostility. This would be particularly true if the group had made no effort to win over other members of top management but had developed an attitude of "you do this or else".

THE FUNDAMENTAL RELATIONSHIPS WHICH AFFECT THE OR/MS ACTIVITY

The OR/MS Activity and the Organization

At some stage during the OR/MS Life Cycle the management of the organization makes a decision to formally introduce OR/MS activities into the organization structure. This is an Authority-Innovation Decision but it is up to individual departments to decide whether or not they will adopt the new activity. The OR/MS activity may be promoted by a highly placed sponsor or it may be left to fend for itself. As the previous section indicated there may be conflict between the organization and the OR/MS group for various reasons. If this conflict is not resolved

the OR/MS group will be rejected by the organization as a whole and will either disintegrate or be disbanded.

It may not be appreciated how many complex relationships exist between the OR/MS activity and the organization. There are in fact four types of interface that can be observed between the organization and the OR/MS activity.[24]

1. With Sponsors

   The sponsor may be a member of top management or alternatively an entire department. The latter type of sponsorship is more likely if the group has been established as a result of an Internal Evolutionary Process. Typical types of functional sponsors are R and D, Planning, and Finance. The role of the sponsor tends to include Auditing, Stabilizing, Innovating and Advising.

2. With Non-OR Staff Groups

   These may include Accounting, Industrial Engineering, Planning, Data Processing. The OR/MS group will be dependent upon these groups for services and information.

3. With Clients or Users

   These are the groups within the organization which make use of the OR/MS activity for services, innovation, and advice.

4. With External Publics

In this case these are external bodies whose activities influence the OR/MS group or whose skills may be drawn on by the group. The type of body concerned may be

- Professional Societies
- Academic Institutions
- Consultants

The final adoption of an OR/MS activity is therefore complicated by the problems involved in maintaining satisfactory relationships with these four different bodies. It is quite possible for internal company politics between two or more of these bodies to cause the Death or rejection of the OR/MS group although the relationships between the groups and all four bodies are satisfactory. For example conflict between a user department (3) and a member of the Non-OR staff group (2) could result in the staff group refusing to provide the OR/MS group with services required for it to continue functioning.

Therefore the process of Adoption of OR/MS activity is far more complex than that normally observed in diffusion studies of social systems generally. Intergroup conflict can result in the rejection of OR/MS activity although all the subgroups involved are favourably disposed towards OR/MS.] debatable

A newly introduced OR/MS group will be fighting many fires simultaneously. Some of these fires will have been caused by attitudes and behaviour of members of the group at one or more

of the four interfaces previously mentioned. However the interfaces between each of the four groups and the other groups may also result in friction which is damaging to the success of the OR/MS group. As a result unless the group is directed by an organizational leader who is acutely aware of developments within the company it may find itself the center of a totally undeserved and unexpected controversy. The management of such a group therefore requires an extremely sensitive individual who is capable of controlling his own people and at the same time servicing the other critical interfaces within the organization. It is obviously impossible for a single manager to tackle this task on his own and hopefully a portion of the load will fall on the shoulders of the sponsor or members of the Non-OR staff groups who are favourably orientated towards the OR/MS group.[25]

The OR/MS Activity and Its Clients

Although the relationship of the OR/MS activity with all four different organizational bodies is important, the adoption, rejection, or discontinuance of an OR/MS group in the long term depends upon the success with which OR/MS-client relationships are developed. Bean has listed the important stages in the growth of a working relationship between an OR/MS group and clients once the group has achieved the Transitional or Maturity stage of the Life Cycle.

1. A Period of Missionary Work: where the OR/MS activity functions in an advisory capacity to a client to assist the client in the solution of problems.

2. A Period of Project Definition: where the OR/MS group attempts to define projects on which members of the group can work.

3. A Period of Project Work: during which OR/MS teams are formed using members of the OR/MS group and the client group, and proposals for the solution of defined problems are made to the client. A percentage of these proposals may be accepted by the client.

4. A Period of Implementation: when formal implementation of a solution is attempted once a proposal is accepted.

5. A Period of Stabilization: when changes instituted during implementation are closely examined to ensure that recommendations are in fact beneficial to the client.[26]

This five stage development process can be ended at any time if relationships between client and OR/MS group deteriorate. Stage 2 can be repeated a number of times before the OR/MS group identifies a project which the client accepts. Stage 3 can be repeated many times on various projects before the client permits the OR/MS group to implement recommendations. It is during Stages 2 and 3 that the influence of the sponsor and the group leader can be extremely important in getting the client to proceed to Stage 4. An OR/MS group can not be regarded as formally adopted by the organization until it has been permitted to implement recommendations on a project. The fear of possible effects of change will

have a considerable effect at this point. Unless the client is receptive to the OR/MS group, and the organizational climate is favourable to change, Stages 4 and 5 may never be achieved.

It is conceivable that an OR/MS group can achieve the Transitional Phase of the Life Cycle, without ever reaching Stages 4 and 5 of the Implementation Cycle. Consequently even though the OR/MS group has been adopted by the organization, OR/MS techniques have not yet reached the Trial stage of the diffusion process. This raises an issue which was briefly mentioned in Chapter 3 and must now be discussed in greater detail.

The previous sections have introduced the concepts of the Life Cycle of OR/MS activity. The reasons for the possible discontinuation or death of an OR/MS group after it has been formally adopted by the organization have been discussed. It is now necessary to examine the factors associated with OR/MS success, in order to be able to provide answers to questions of the type:

- How does one measure the effectiveness of an OR/MS group?
- How can an OR/MS group increase its effectiveness?

The Concept of Effectiveness or Success

The measurement of OR/MS Effectiveness or Success is extremely difficult. Radnor and Neal produced a paper devoted to the identification of the factors associated with Effectiveness. The authors proposed a definition of Effectiveness as the ratio

of Proposals Implemented to Total Proposals Submitted by the OR/MS group in an organisation.[27]

There are problems associated with Implementation which make it very difficult to obtain a really true measure of Effectiveness. It is possible to define Effectiveness as:

$$\frac{\text{Number of proposals accepted}}{\text{Number of proposals made}} \qquad (A)$$

or

$$\frac{\text{Number of proposals implemented}}{\text{Number of proposals made}} \qquad (B)$$

or

$$\frac{\text{Number of proposals successfully implemented}}{\text{Number of proposals made}} \qquad (C)$$

The final definition (C) would appear to be a better evaluation of the Total Effectiveness of a group. "Successful Implementation" is much influenced by the phase the OR/MS activity has reached in its Life Cycle, as well as the current attitudes and behaviour exhibited towards the activity. To leave the definition as (B) at the "accepted and used" stage would in effect only indicate the acceptance ratio of OR/MS activities. There seems to be a case for a dual definition of Effectiveness in which (C) measures the extent to which all proposals originating from the OR/MS activity achieve desired results, whilst (B) measures the extent to which proposals are implemented. There could possibly be a correlation between C/B and the stage in the Life Cycle the group has reached.

what kind?

Unfortunately due to the problems of establishing universally acceptable measurements in terms of financial savings etc. it

has not been possible to proceed significantly in this area. The concept of "Effectiveness" has subsequently been renamed "Success" where Success is defined as the percentage of OR/MS projects completed and used.[28, 29] The problem of deciding when a project is "successfully" implemented makes it impossible to employ definition (C).

Neal and Radnor published results of a study carried out on the basis of personal interviews with OR/MS managers, practitioners and clients in which they attempted to measure the relationship between the Formalisation of Procedures and Success.[30] In this study they used various measures to indicate Success:

1. Percentage of Jobs used.
2. Success Levels as Perceived by the OR/MS manager.
3. Top Management Support as Perceived by the OR/MS manager.
4. Client Receptivity.
5. Degree of Project Backlog.
6. Percentage of Projects generated by Non-OR/MS Personnel.

These measures were weighted and combined to give an overall Success Factor.

The success factor combines hard data measures such as "Project Backlog" and "Projects generated by Non-OR/MS people" with measures which depend upon the perception of the OR/MS manager.

The results of the study confirmed - as discussed in Chapter 3 - that there was a significantly positive relationship

between the Degree of Formalisation and Success of an OR/MS group.[31]

The authors decided to test further relationships with the Success Factor and the Degree of Formalisation, assuming that these could both be dependent variables to some third factor. The results of these tests are interesting although, as Neal and Radnor mention, formalisation could be more of an indicator rather than a determinant of success. As a result correlations could in fact demonstrate either causation or correspondence.

The list of findings are presented below. They tend to confirm many of the relationships which have been expressed previously:

1. An OR/MS manager with an organizational orientation (as distinct from a professional OR/MS man) tended to be associated with OR/MS group success.

2. Top management involvement and OR/MS group success are significantly related.

3. The larger the size of an OR/MS activity the greater the chances of proceduralization, top management support and therefore a correspondingly higher implementation rate and success.

4. The larger the size of an OR/MS group the greater the extent of OR/MS activity diffused throughout the organization.

Neal and Radnor stress that these findings are preliminary and that dependencies have not been clearly established. There is a very likely possibility that several of the positive correlations, rather than causing success, might be an indicator of a successful group. However the conclusions reported appear to confirm observed behaviour. There is nothing that looks totally unexpected and many of the findings can be predicted by a study of the diffusion process of OR/MS activities.

Top Management Support and OR/MS Success

Neal and Radnor found a positive correlation between Success and Top Management support. Radnor and Bean investigated the relationship between Top Management Support and Change Agent Success.[32] There are three ways in which top management can influence the Success or Failure of a Change Agent. Success in this instance is defined as "facilitating the relationship between the Change Agent and those Managers the Change Agent is intended to serve". (Note that in this instance the Change Agent is the OR/MS activity and not the sponsor. Rogers and Shoemaker regard the Change Agent as the person who influences innovation decisions i.e. the sponsor.)

1. Top management must locate the Change Agent (OR/MS activity) in that place in the organizational structure where it can best establish itself. They must also identify the best long term location for the Change Agent. "Where can it best win the legitimacy it needs in the organization to be accepted

and to be able to operate efficiently, while allowing its members to protect their professional integrity."[33]

2. The amount of resources allocated to the Change Agent must be carefully determined. A substantial investment may result in a significant amount of change in the organization, the less the investment the smaller the change.

3. The amount and nature of support given to the Change Agent by top management has a direct influence upon the degree to which clients may be encouraged to employ or ignore the services of the Change Agent. For example by demanding information and analysis from organizational members in such a way that the Change Agent must be employed can indirectly increase the organizational acceptance of the Agent.

The third method of assisting the introduction of the OR/MS activity is of particular interest. "Top management support" is difficult to define and even more difficult to measure. Research has shown that different people in the same organization will rate top management support for the OR/MS activity completely differently. Some will rate management as being disinterested whilst others will rate management as being totally committed.

From a sample of 27 companies Radnor and Bean checked the Receptivity of Clients in each company with the perceived level of Management Support indicated by the OR/MS manager.

They found a positive relationship between the level of Management Support and the level of Client Receptivity. Similar data was reported in a study by Radnor, Rubenstein and Tansik.[34]

Radnor and Bean examined the consistency of perceived management support for OR/MS activity within an organization and found that

(a) In the Introductory and Transition stages of the development of OR/MS activity Management Scientists' expectations of top management support may in fact exceed what top management is willing to do.

(b) Line managers have a lower perception of top management support than is actually the case.

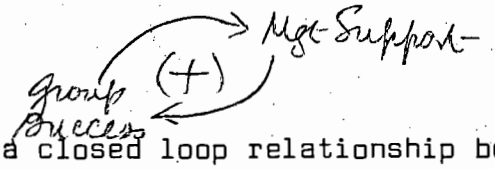
(c) In the Maturity stages the extent to which top management is prepared to support the OR/MS group gradually becomes closer and closer to the level of the Management Scientists' expectations.[35]

These observations can be explained on the basis that initially top management is uncertain of the potential applications of OR/MS and makes a tentative commitment in order to see what is involved. During the Introductory and Transitional periods they may appear to be supportive but in fact may be unwilling to commit themselves completely. However if the OR/MS activity succeeds and becomes established in the organization then top management may

increase the level of support to certain OR/MS activities and withdraw support from other areas entirely. It is during the Transitional phase that many OR/MS groups are relocated in the organization. Research has shown that it is about this time that management support increases. This can be explained by top management beginning to identify the possible applications of OR/MS more clearly and by moving the group to an improved organizational location. Top management support increases as the group develops a definite charter and works on more clearly defined projects.

Several investigators have found that there is a relationship between the degree of professionalism within the OR/MS group and the level of top management support. Professionalism can be interpreted in terms of the manner in which projects are handled, the formal procedures which exist, and the attitudes of the OR/MS group members. All these are attributes of a group that has found its feet in an organization and has identified the areas in which it will work.

Is this easy to measure?



It appears that there is a closed loop relationship between management support and group success. As the group completes more meaningful tasks, top management support increases, this in turn gives the group enhanced status and greater stability. The group is more in a position to decide what it will do and how it will operate, top management is able to identify this by external manifestations such as a greater degree of procedural formalisation and a greater proportion of successes. This in turn increases top Management support.

There is an additional factor that appears to increase the chances of top management support over time. Research has shown that managers are more favourably orientated towards OR/MS if they understand what the group is doing.[36] This understanding is achieved by acquisition of a knowledge of OR/MS techniques. This knowledge could be acquired outside the environment of the organization, however it is more likely for it to be developed over a period of time within the organization by supervision of the activities of the OR/MS group. Managers are able to give greater support to projects, if they have enough knowledge of the techniques involved and the possible payoffs, than they are when the subject is totally new. Management support will therefore increase as the group progresses from the Introductory Phase to Maturity.

The Life Cycle and OR/MS Success

The previous sections were devoted to an examination of the concept of OR/MS success and its relationships with Top Management Support, Change Agent Activity, Proceduralization etc. It has also been found that the effect of success on an OR/MS activity is very much linked to the stage of the Life Cycle that has been attained by that activity.[37] For example during the Introductory or Transitional Phases an exceptional contribution by an OR/MS group can enhance the status of the Group far more significantly than would be the case during the Maturity Phase when the group is already established and accepted. Conversely, an unsuccessful project can have a far greater adverse affect on a newly established group than it would have on a group in the Maturity Phase.

This can be explained in terms of the basic concepts of Authority-Innovation Decision Making discussed in Chapter 1. In this type of situation an innovation is adopted by a decision unit for use by an individual in a subordinate position. In the Introduction or Transitional Phases, the decision unit seeks reassurance that the adoption of the innovation was in the best interests of the organization. The decision unit has to appear supportive of the innovation in the early stages of the diffusion process. However as soon as the innovation justifies the faith of the decision unit - in this case by completing a successful project - then the perceived attitude of the decision unit and its actual beliefs are congruent. As a result OR/MS success in the Introductory Phase is far more important to Management (the decision unit) than it is in the Maturity Phase.

As far as the individual in the subordinate position is concerned, the position is very much the same. The individual will either be a "client" who has been forced to adopt the OR/MS activity or merely an "observer" department in the organization which has not been a client at this point in time. A successful OR/MS project, in the eyes of both client and observer, will go a long way to achieving congruence between the perceived support of the decision unit and the feelings of the subordinate. Consequently the impact of OR/MS success in the Introductory Phase can be far greater than it would be in the Maturity Phase for client and observer alike.

The list of the ten factors linked to success provides an extremely useful checklist with which to plan the strategy of any OR/MS group at various stages of the Life Cycle. It is helpful for OR/MS leaders to highlight areas of weakness. Unfortunately it is not possible to assign a weight to individual factors as they are inter-related and reinforce one another.

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Using the list as a check, it will be seen that several factors will be positively influenced by success. There will be a positive relationship between Actual Success and factors 1, 2, 5, 6, 7, 8 and 10 and a negative relationship with factor 9. There is thus a multiplier effect which is best defined as "success breeds success". For example, Actual Success will result in greater management support, increased client receptivity, enhanced reputation and influence, reduced opposition etc.

Nonquant.

The impact of success will obviously be affected by the stage of the Life Cycle that has been attained; in fact the Law of Diminishing Returns must apply as the group proceeds along the Life Cycle. By the time the Maturity Phase has been reached the perceived level of management support and the actual level of management support will be similar; the influence and reputation of the group will be firmly established; the level of opposition will be reduced to individuals who are implacably opposed to OR/MS activity - typically those individuals with Traditional norms.

Consequently, although an OR/MS group can enter the Death Phase at any stage of the Life Cycle as a result of one or a number of unsuccessful projects, the probability of this happening will decrease as the group proceeds from the Introductory to Maturity Phases. It is important therefore that the group selects projects which have a high probability of success in the early phases of the Life Cycle. In the Maturity Phase more demanding projects can be undertaken as the penalties of failure are not as great.

CONCLUSION

Basic research on the diffusion of innovation in social systems has inciated that an individual faced with an innovation goes through a four stage process prior to making the decision to adopt the innovation - Awareness, Interest, Evaluation and Trial. He may decide to reject the innovation at any stage of the process or he may decide to discontinue his use of the innovation after previously adopting it.

The diffusion of OR/MS activity in an organization is an example of an Authority-Innovation Decision where a decision to make use of an innovation is taken by a superordinate decision unit and subordinates are then ordered to adopt the innovation. The peculiar nature of OR/MS activity, which has to depend on the availability of worthwhile projects for survival, makes it necessary to propose a specific model with which to explain the diffusion of OR/MS.

The so-called "Life Cycle" model postulates that the diffusion of Management Science in an organization follows a four stage process.

1. A Pre-Birth Phase when there is an awareness of OR/MS in the organization but no formal allocation of resources

2. An Introductory Phase when management grants a temporary allocation of resources for specific OR/MS activity

3. A Transitional Phase in which OR/MS is not a permanent organizational activity but management has a commitment to OR/MS activities

4. Maturity Phase when resources have been allocated and the OR/MS activity is a permanent part of the organization structure.

The fifth and final stage of the process is Death. This can occur after any of the intermediate stages and will return the cycle to the Pre-Birth Phase.

OR/MS activities may move from the Pre-Birth Phase to the Introductory Phase as a result of one, or both, of two possible processes. The formal group may be created as a result of demand by departments within the organization - an Internal Evolutionary Process. Alternatively a highly placed individual in the organization may decide to sponsor the introduction of OR/MS activity - an Externally Induced Process. Both processes have been found to be influenced by a variety of factors such as

An additional problem that confronts OR/MS groups' activities within an organization is the fact that they may become victims of interdepartmental disputes. This situation can also result in their eventual disintegration. OR/MS groups have to maintain satisfactory relationships with four different groups:

(i) Sponsors
(ii) Non-OR staff groups
(iii) Clients
(iv) External Public

A conflict between the client of an OR/MS group and a non-staff group, such as EDP, may result in it being impossible for the group to have access to data or EDP assistance. It is therefore necessary for an OR/MS group to maintain satisfactory relationships at all four interfaces and at the same time be acutely aware of internal organizational politics.

Nevertheless the most important relationship that must be maintained by the OR/MS group is with its clients. An OR/MS activity follows a five stage process when establishing itself with a client.

(i) A period of Missionary Work
(ii) A period of Project Definition
(iii) A period of Project Work
(iv) A period of Implementation
(v) A period of Stabilization

It is conceivable that a group progresses rapidly from (i) to (iii) with a client and finds it extremely difficult to implement recommendations. This raises the problem of arriving at a method of quantifying the Success of OR/MS activities. In order to compare the effectiveness of OR/MS groups in the Maturity Phase (say) it is necessary to find some way of ranking their performance.

The concept of OR/MS Effectiveness or Success has been the subject of considerable research, but as yet no really meaningful results are available. Success is generally defined as the "Percentage of OR/MS projects completed and used", but may also be defined in terms of criteria such as "The Degree of Project Backlog", etc. Top management support appears to be the most critical factor in influencing OR/MS success but this in itself is a complicated concept to quantify.

The impact of success on an OR/MS activity is very much dependent upon the stage of the Life Cycle that the activity has achieved. Success in the Introductory and Transitional Phases will greatly enhance the perceived status of the group, top management support, reputation, etc. During the Maturity Phase the effect of success may be marginal. Conversely, failure during the Maturity Phase is not as likely to force the group into the Death Phase as it might do during the Introductory and Transitional Phases. Therefore the choice of projects selected during the early phases is extremely important, and only those with guaranteed payoffs should be attempted.

REFERENCES

CHAPTER 4

1 A.H. Rubenstein, M. Radnor, M.R. Baker, et al, "Some Organizational Factors Related to the Effectiveness of Management Science Groups in Industry," Management Science, Vol. 13 (April 1967), pp. B508-B518

2 Ibid., p. B510

3 Ibid., p. B512

4 A.S. Bean, "Some Considerations on the Management of Management Science Groups," Paper presented at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969, pp. 7-8

5 Ibid., p. 9 (adapted)

6 Ibid., p. 9 (adapted)

7 Ibid., p. 12

8 Ibid., p. 12

9 E.M. Rogers and F.F. Shoemaker, Communication of Innovations, A Cross Cultural Approach (New York: The Free Press, 1971), pp. 311-312

10 L.G. Scott, Organization Theory (Homewood, Illinois: Richard D. Irwin, 1957), pp. 122-123. Cited by C.V. Grant, "Management Scientists as Change Agents," Systems/Stelsels, November/December 1972, p. 4

11 F.E. Kast and J.E. Rosenzweig, Organization and Management - A Systems Approach (New York: McGraw Hill, 1970), p. 110

12 E.M. Rogers, Diffusion of Innovation (New York: The Free Press, 1962), p. 5

13 E.M. Rogers and F.F. Shoemaker, op cit., p. 248

14 C.V. Grant, op cit., p. 6

15 A.S. Bean, op cit., p. 8

16 C. Argyris, "Management Information Systems," Management Science, February 1971, pp. B(275-291)

17 Ibid., p. B285

18 A. Pettigrew, "Intergroup Conflict and Role Strain," Journal of Management Studies 5(2) (May 1968), p. 211

19 C. Argyris, op cit., p. B-286

20 Ibid., p. B-287

21 C.V. Grant, op cit., p. 6

22 C. Argyris, op cit., p. B-291

23 E.A. Schem, Process Consultation; its role in organization development (Reading, Mass: Addison-Wesley, 1969), p. 73. Cited by C.V. Grant, op cit., p. 10

24 A.S. Bean, op cit., p. 11

25 A.H. Rubenstein, "Integration of Operations Research in the Firm," The Journal of Industrial Engineering, Vol. XI, No. 5 (1960)

26 A.S. Bean, op cit., p. 15

27 R.D. Neal and M. Radnor, "The Relation between Formal Procedures for Pursuing OR/MS Activities and OR/MS Group Success," Journal of Operations Research Society of America, Vol. 21 (1973), pp. 451-474

28 M. Radnor, A.H. Rubenstein and D.A. Tansik, "Implementation in Operations Research and R and D in Government and Business Organizations," Journal of Operations Research Society of America, Vol. 18 (1970), pp. 961-991

29 E. Turban, "A Sample Survey of Operations Research Activities at Corporate Level," Journal of Operations Research Society of America, Vol. 20 (1972), pp. 702-721

30 R.D. Neal and M. Radnor, op cit.

31 Ibid., pp. 461-462

32 M. Radnor and A.S. Bean, "Top Management Support for Management Science," Omega, Vol. 2 No. 1 (1974), pp. 63-75

33 Ibid., p. 65

34 M. Radnor, A.H. Rubenstein and D.A. Tansik, op cit., pp. 967-991

35 M. Radnor and A.S. Bean, op cit., p. 66

36 Ibid., p. 69

37 A.H. Rubenstein, M. Radnor, M.F. Baker, et al, op cit., p. B510

38 Ibid., p. B510

CHAPTER 5

DERIVATION OF AN INFORMATION SYSTEM DEVELOPMENT RATING

The Northwestern Research Group found that OR/MS activities are very much dependent upon DP/MIS support for success and stability. The Research Group concentrated its attention on companies which were included in the Fortune 500 listing and it is therefore likely that the majority of these large organizations at least achieved a certain minimum level of Information Systems development. As a result it was not necessary for the Research Group to include Systems Development as a factor which would significantly affect the diffusion of OR/MS.

The South African situation is very different. Many local organizations have non-existent Management Information Systems. It is only during the last ten years, with the advent of computers that the importance of formal systems development has been recognised. One cannot assume a similar level of formally established information systems when comparing local OR/MS activities. This thesis hypothesises that Systems Development is one of the critical factors influencing the diffusion of OR/MS in South Africa, and for the successful passage from the Prebirth to Maturity Phases of the Life Cycle a certain minimum level of Systems Development is essential.

The relationships between OR/MS and DP/MIS are briefly restated in this chapter and Systems Analysis and Management Information Systems are defined. In order to arrive at a Rating Scheme for Information Systems Development the concept of an Operational Control Systems Classification is introduced and the various Modules of the Classification are presented in detail. The Rating Scheme, which is subsequently used to establish the level of formal Systems Development encountered in the field studies, is discussed.

RELATIONSHIP BETWEEN OR/MS AND MIS

A working definition of OR/MS was established in Chapter 2 which identified OR/MS activities as those "which were performing work utilizing the newer methods of mathematical analysis and/or were involved in non-routine computer systems activities".

Following this definition it was possible to identify several organizational activities that could be included as part of the OR/MS concept. These activities included Operations Research, Management Science, Systems Analysis, etc. As many of these organizational activities performed similar functional tasks, the conclusions reached at a conference in America in 1968 were adopted.[1] These included the decision to use "Management Science" as an umbrella term to cover all scientific entities such as Systems Analysis or Management Information Systems, which make use of specific Operations Research Techniques.

There is thus a very close relationship between Management Information Systems (MIS), Systems Analysis (SA) and Management Science (MS). In many instances the difference is purely as a result of nomenclature adopted in an organization.[2] The relationship exists because both MIS and SA make extensive use of recognised Operations Research techniques. Therefore the observed tendency of OR/MS activities to gravitate to DP/MIS departments is easily explained in terms of mutual understanding and mutual need.[3]

In many organizations in America the DP/MIS function today has achieved Maturity and in many cases has gained "essential" status. It is only natural for OR/MS groups to find stability in a function which provides access to Data Processing, uses and understands Operations Research techniques, and is aware of the problems that face any innovative activity.

The research currently being carried out in America has so far only identified the beginning of a trend of diffusion of OR/MS groups into DP/MIS functions. In the last ten years the percentage of OR/MS groups located in MIS has increased from zero to twenty-five percent.[4] It is too early to say whether this trend will continue but the change is sufficiently marked to anticipate increased diffusion in the future. It is interesting to speculate on the final outcome of this diffusion which could result in the majority of MS and MIS groups merging.

SYSTEMS ANALYSIS AND MANAGEMENT INFORMATION SYSTEMS

At this stage both activities have been described as scientific entities which employ recognised Operations Research techniques and are classified as members of the Management Science group of functions. This does not explain the nature of the activities nor the concepts involved. In order to do this it is necessary to examine some concepts relating to the structure of organizations.

> A business organization can be viewed as a series of large information networks connecting the requirements for information in each decision-making process with the sources of data and extending throughout all of the business process, including the actions by users of the information. In large complex business organizations, the different operations of a given business organization can be described as separate information networks, with one giant overall information network superimposed on top of the individual information networks.[5]

The inter-relationships and inter-dependencies of the separate information networks in the business environment has attracted the attention of workers in the field of general Systems Theory. The goal of general Systems Theory is to establish a body of systematic theoretical constructs which describe the relationships of the empirical world.[6] The long-term objective of the Theory is to develop a set of analytical and communications vehicles that could connect and inter-relate all disciplines, not necessarily those associated with business.

Some of the theory of General Systems has been used to establish a foundation for studying the information requirements of decision-making processes in business. This foundation has been expanded using techniques of behavioural science, mathematics and scientific method to arrive at an analytical approach for studying information networks within an organization called the Information System Approach. This can be described as a vigorous and systematic method of observing, analysing, evaluating and modifying a business organization or any segment or part thereof.[7] Practitioners of these systematic methods are referred to as "Systems Analysts".

Essentially the Systems Analyst attempts to:

group major decisions that business management must make (both informally and formally, explicitly or implicitly - thus, all decisions) into categories that are based upon a combination of:

1. The general area the decision concerns
2. The time dimension of the decision process
3. Similar requirements for information in the decision process.[8]

A group of decisions which are linked due to similarities in these three areas form the basis of an Information System.

The Systems Analyst traces all information flows which are linked to this group of decisions and decision-making processes.

These flows take no account of organizational boundaries and so present a far more valid picture of the management process in an organization. This network of information flows linking the group of related decisions constitutes the "System" and since the System depicts the flow of information, each network portrays a particular Information System. As these Systems depict the process by which management decisions are taken based upon data transmitted in the network they are normally referred to as Management Information Systems.

Once the Systems Analyst has established what Information Systems exist within an organization it is necessary to specify:

- What information is required for each of the decision-making activities
- Where the information can be obtained for each activity

It is at this point that the relationship with OR/MS is reinforced as it is often necessary for the Systems Analyst to apply "Management Science tools and techniques in the matching of requirements for information with sources of data".[9] The analyst is then in a position to evaluate the existing information flows in terms of requirements and data sources and finally to design new information systems which make better use of the data capturing, processing and reporting facilities possessed by the organization.

The analyst is now in possession of an overall system model of the entire organization which depicts each individual Information System. Theoretically the final stage would be to produce a Total Management Information System which is "one giant overall information network superimposed on top of the individual information networks".[10]

The Concept of Total Systems

During the period 1960 - 1970 the concept of Totally Integrated Management Information Systems received a great deal of publicity in America. In practice it was found that, although certain individual information systems lend themselves to

integration with other information systems, the change from partial integration to total integration was an expensive and risky step. Blumenthal comments:

> The apparent penchant in some quarters for advocating a single great leap, rather than slow escalation, to the large integrated systems goal has contributed to the unprofessional aura in altogether too many of the breezily written articles on total-management-information systems.[11]

One of the fundamental problems facing the disciples of total MIS is the difficulty they encounter in producing meaningful cost justifications for the introduction of these systems. Although information systems need not be computerized, it is apparent that the greater the amount of data that must be processed, the more likely it is that some form of computer assistance will be required. Partially integrated systems can often be accommodated on existing data processing equipment currently handling routine applications such as payroll and stock. However the closer the approach to total systems, the more likely it is that additional expenditure will be required on more sophisticated hardware and the additional software requirements are often prohibitively expensive.

The only valid way of justifying this expense is by estimating the financial returns resulting from the investment. This raises the problem that:

> ... most of the benefits of a management information system are of 'intangible' nature. Clearly what is needed are new methods of justifying information-systems costs by somehow quantifying these heretofore 'intangible' benefits. Until this can be done, it

> is difficult to see how management can be persuaded to commit substantial company resources to truly effective information-systems development.[12]

There are portions of the total MIS which are being integrated to a greater degree both in America and South Africa. However there is not as yet any clear indication that successful applications are being made in areas other than Finance/Accounting and Logistics such as Order processing, Purchasing, Inventory control and Production scheduling. The cost/benefit justification in these areas is far easier to establish, if only on the basis of savings achieved as a result of increased speed of processing.

As a result of the difficulties encountered by the relatively few firms that have attempted to install Total Systems there are fewer "breezily written articles" on the subject. Experience has shown that there is a point of diminishing return beyond which greater commitment to Total Systems can adversely affect the operation of existing independent systems. However many authors in the field indicate that, whilst the Total Systems concept is an ideal rather than a goal, improvements in systems design will come as a result of a gradual movement towards Total Systems.

INFORMATION SYSTEMS IN THE CONTEXT OF SOUTH AFRICA

It is difficult to compare the state of systems development in South Africa with America. The Northwestern Study Group has worked exclusively in American government departments or in large American companies. In the 1970 OR/MS survey carried out in 108 companies, only four companies were not large enough to find a place in the Fortune listing of the largest American companies.[13] Only three companies had turnovers less than $200 million annually.

The sheer size of these companies has a considerable effect on the number and size of staff departments that will find a home in the organization structure. All the OR/MS groups in the American study had access to in-house or time sharing computer facilities.[14] The advent of third generation machines in the mid-1960's which were capable of handling complex OR/MS models had a tremendous impact on the development of these groups. Generally installations of this size would be staffed by DP/MIS professionals and this would have a significant effect on the development and efficiency of sophisticated Management Information Systems networks within the respective companies.

There are probably fewer than 1 000 computers in South Africa whilst it is estimated that in America there are over 70 000. In terms of a Management Information Systems orientation this simply means that there are far fewer systems analysts or experienced MIS groups in industry locally.

The ten field studies which are described in a subsequent chapter were conducted in companies with annual turnovers ranging from R10 million to R300 million. The only similar feature in all ten companies was the OR/MS activity that was being investigated. Only five of the ten had in-house computer installations, and only four had formal Data Processing divisions which housed systems analysts. As the field studies indicate the level of systems development in the ten companies varied significantly. The relatively uniform level of computer support and systems sophistication encountered by the Northwestern Group in the 1970 OR/MS survey definitely does not exist in the sample of companies examined in this thesis.

The reasons for the selection of the ten companies in the sample are given in more detail later. However it is possible to justify the choice of organizations with differing levels of systems development as being typical of the situation in South African business. It is only during the last ten years that computers have effectively penetrated the South African market, and it is only during this time that the importance of effective information systems has begun to be appreciated. This is mainly due to the large percentage of family owned businesses with traditional norms that exist in South Africa. Many of these companies dabbled in data processing in the early 1960's with unfortunate results.

It is hypothesised that the introduction of OR/MS activities into this type of organization would be equally

traumatic. On this basis then, the level of systems development is proposed as a measure of the extent to which Top Management in a South African company is receptive to Innovation. Companies that have undergone the transition to computers and the accompanying implementation of formal MIS (i.e. with modern norms) should be more receptive to OR/MS than companies with undeveloped systems and Traditional norms.

In order to establish a Systems Rating with which to assess individual organizations it is necessary to examine the elements of a formal MIS in more detail. This can be achieved on the basis of the concept of an Operational Control System which is described in the following sections.

OPERATIONAL CONTROL SYSTEMS

In South Africa, with the exception of a handful of particularly progressive organizations, the concept of Totally Integrated MIS is unlikely to become reality within the immediate future. However many local companies have developed extremely efficient free-standing Information Systems. In order to do this it has been necessary to establish formal Systems Planning objectives to prevent duplication of effort and to ensure a uniform and consistent approach to systems design. These objectives are aimed at achieving a balance between the impractical Total Systems approach and a proliferation of small free standing systems.

The following list details seven fundamental systems planning objectives that must be borne in mind if the development of individual information systems is to be successful. It should be remembered that although a Total Systems approach may never be contemplated it is important to ensure that individual systems are compatible.

1. To avoid the overlapping development of major systems elements which are widely applicable across organizational lines, when there is no compelling technical or functional reason for difference.

2. To help ensure a uniform basis for determining sequence of development in terms of potential payoff, natural precedence and probability of success.

3. To minimize the cost of integrating related systems with each other.

4. To reduce the total number of small isolated systems to be developed, maintained and operated.

5. To provide adaptability of systems to business change and growth without periodic major overhaul.

6. To provide a foundation for co-ordinated development of consistent comprehensive corporate-wide and inter-organizational information systems.

7. To provide guidelines for and direction to continuing systems-development studies and projects.[15]

These objectives are the pivot of Sherman Blumenthal's book "Management Information Systems".[16] The main feature of the book is the identification of the fundamental Operational Control Systems which are generally encountered in most organizations. These Systems are selected on the basis of certain specified traits and relationships, and the modules are designed so as to meet the seven previously stated Systems Design objectives.

Operational Control Information Systems consist of routine activities and associated transaction-based data processing systems that would continue in the absence of management.[17] These Control Information Systems should handle the processing of day-to-day data and should highlight deviations from expected performance by means of Exception Reports. In fact these are the systems which must exist to support the action and decision subsystems of management control systems.

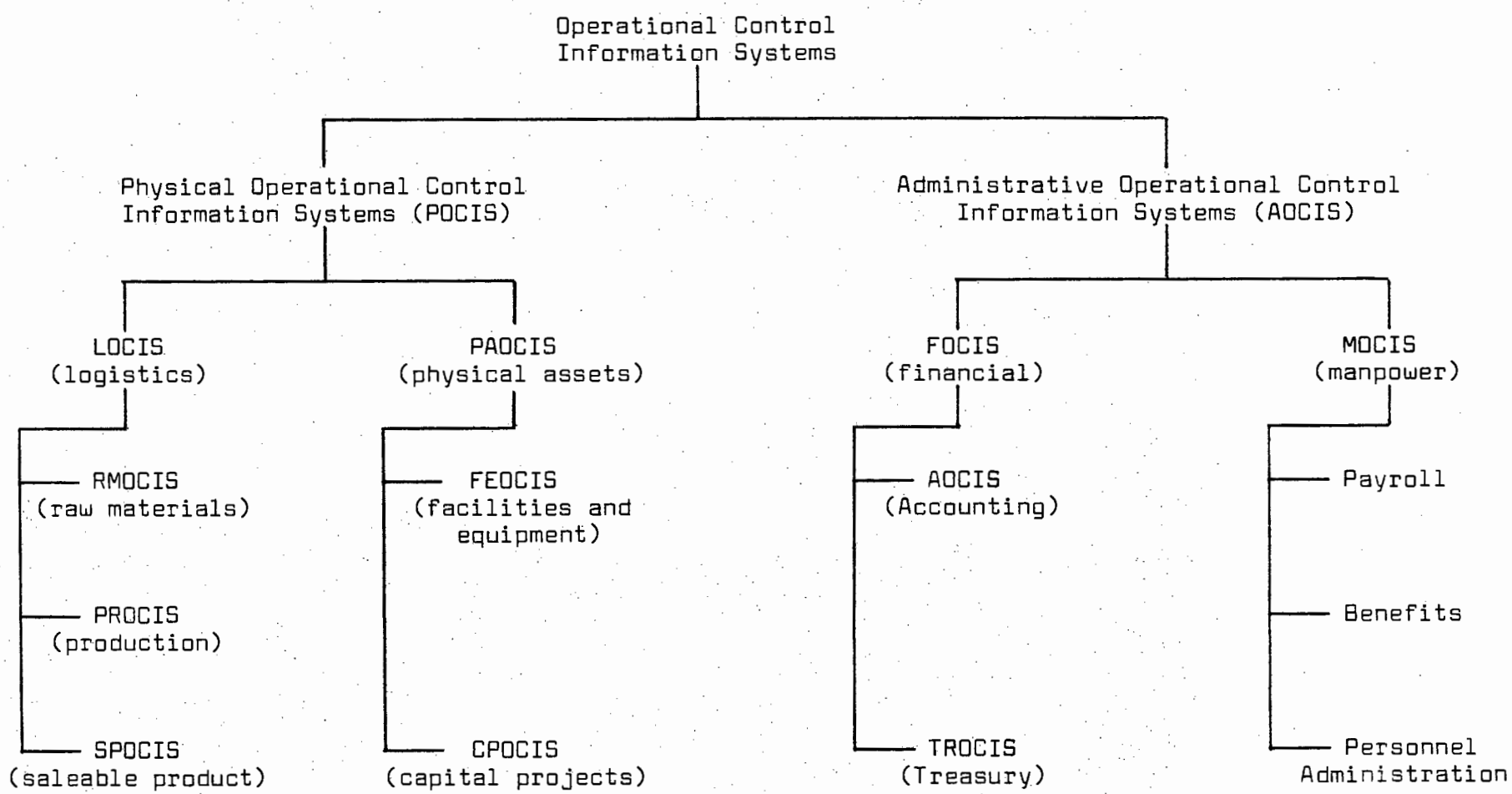
The relationship between the various subsystems of the Total Operational Control Information System is depicted diagrammatically in Figure 3. The relationships shown highlight the areas where integration of individual subsystems is possible. For example, the Logistics Operational Control Information System (LOCIS) is concerned with the flow and transformation of materials and services occurring between the company's interfaces with the supplier on the one side and the customer on the other. The subsystems involved in LOCIS are:

- RMOCIS - Raw Material Operational Control Subsystem
- PROCIS - Production Operational Control Subsystem
- SPOCIS - Saleable Product Operational Control Subsystem

Typical of the type of information being stored and processed in any one of these would be the following:

F I G U R E 3

CLASSIFICATION OF OPERATIONAL CONTROL SYSTEMS[18]



For Raw Materials Orders

- Production orders awaiting raw materials scheduling
- Raw-materials orders awaiting requisition action
- Requisitions awaiting purchase action
- Replenishment orders awaiting purchase action
- Open purchase orders awaiting delivery
- Delivered purchase orders awaiting payment

Each one of the subsystems of LOCIS is capable of existing independently but each relies on the others for input information. It will be readily apparent that there are a number of recognised Operational Research techniques which could be integrated with the LOCIS system to perform monitoring and decision-making duties. For example Table 8 shows the type of activities performed in the Saleable Product Operational Control Subsystem - SPOCIS. A large proportion of the Distribution and Finished Inventory Control activities could be combined into a typical Operations Research model which accepted inputs from the rest of the SPOCIS file.

The Implications of Formal Systems Design

The relationship between the subsystems in each of the four legs of the Operational Control System classfication can be established for any organizational structure. Figure 4 depicts the possible relationships between the three subsystems of LOCIS and shows the master files which would have to exist before any attempt could be made to integrate the three subsystems and run them routinely on a computer.

TABLE 8

ILLUSTRATIVE ACTIONS IN SPOCIS[19]

Order Entry

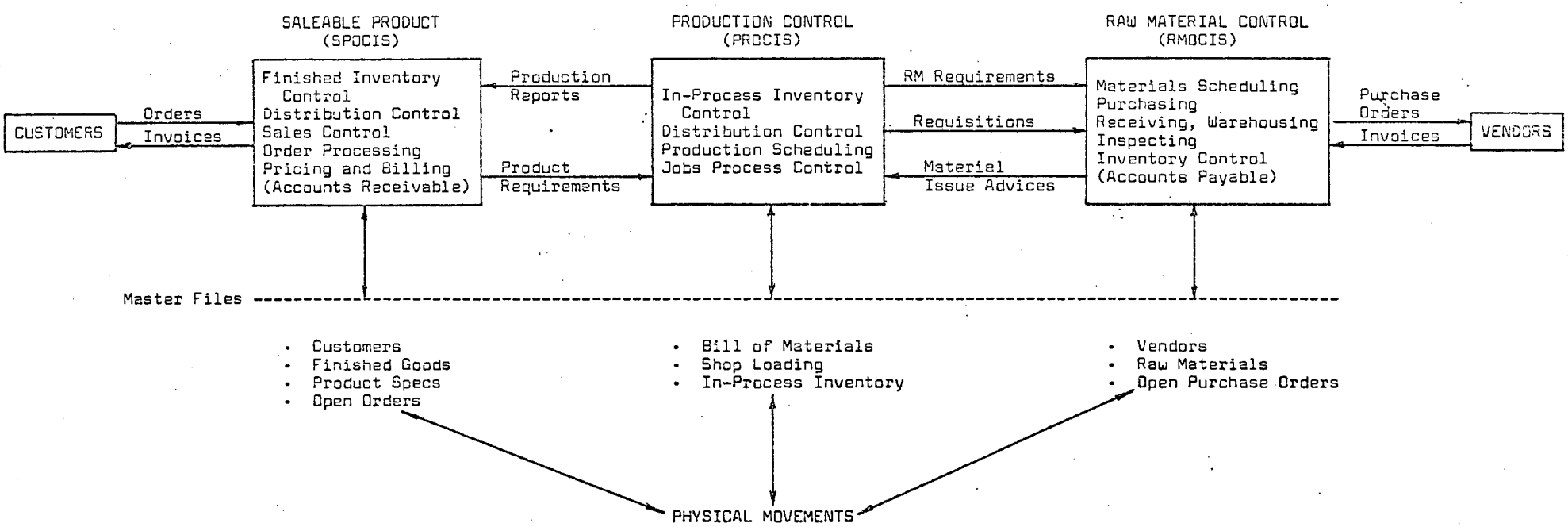
1. Receive original and change orders
2. Receive product information
3. Relate customer need to product
4. Receive customer data
5. Receive customer inquiries
6. Answer customer inquiries
7. Transmit order status information to customers - price, delivery date, etc.
8. Edit received information
9. Establish priority
10. Transmit order
11. Reprocess order errors

Order Processing, and Pricing and Billing

1. Calculate price
2. Check credit
3. Check for special charges
4. Check discount and delivery terms
5. Establish open order record
6. Determine shipping location
7. Reserve material for shipment
8. Produce shipping orders and transmit to shipping points
9. Select transportation mode and carrier
10. Calculate freight charge
11. Update product file
12. Update inventory files
13. Update customer file
14. Update miscellaneous files - excess freight cost etc.
15. Produce and transmit shipping reports
16. Receive and process production reports and schedules
17. Update open order files
18. Prepare and transmit customer acknowledgements
19. Prepare and transmit invoices, dunning notices
20. Update accounts-receivable file, process payments
21. General data for distribution and production planning and scheduling
22. Transmit order-disposition notice to sales office

F I G U R E 4

LOCIS - LOGISTICS OPERATIONAL CONTROL INFORMATION SYSTEM



The diagram clearly shows the level of systems definition that is required before a company can even begin to think of implementing partially integrated Operational Control Information Systems. However the listing of components of SPOCIS demonstrates that most of the activities are fundamental and would be routinely performed in an organization which manufactures inventory for subsequent sale. The problem is that there is a considerable investment in systems analysis, systems design and formal clerical procedures before an informal manual system can become operational as a formal Operational Control System.

In particular the creation of the necessary master files to handle current and historical information would represent a major task to organizations that have employed informal techniques in the past. The introduction of many recognised Operational Research activities would be impossible due to the absence of current and historical information with which to build and test models of decision situations.

Nevertheless the concept of the Operational Control System classification is extremely useful when evaluating the state of systems development within an organization. Although not all of the ten subsystems shown in Figure 3 may be encountered in a particular business, the classification can be used as a benchmark to establish the degree to which formal systems exist and to pinpoint areas where routine decisions are made in the absence of adequate information. The availability or lack of

the essential data files will in turn influence the chances of implementing Operational Research techniques in the various subsystems.

The field studies show that the degree to which formal systems exist is very often a function of the organizational structure of the company. Certain departments may have carried out their own systems analysis and design and as a result the necessary systems specifications, file specifications and clerical work procedures will be implemented and operating. This is usually due to the efforts of one or more of the management team of the department or division and will not be common to the entire organization. The problems of introducing OR/MS activities into this type of department will often be very much less than those normally associated with the introduction of change. The OR/MS group will be operational far more rapidly as data gathering and problem definition will be relatively easy. This is typical of the Internally Evolutionary Process, in which a single department with more Modern norms than the remainder of the organization is better prepared for the introduction of OR/MS. Unfortunately this does not reduce the problems involved in achieving the diffusion of OR/MS activities into the other more Traditional departments in the company.

The final section in this chapter is devoted to establishing the essential features of each of the subsystems included in the four major sections of the Operational Control Classification.

LOCIS - Logistics Operational Control System

PAOCIS - Physical Assets Operational Control System

FOCIS - Financial Operational Control System

MOCIS - Manpower Operational Control System

Once the key features of each subsystem in the four sections have been identified, they can be used as a checklist to establish the degree to which formal information systems exist within any organization. This provides a Systems Rating which can be used to forecast the possible use of OR/MS techniques in in the organization.

ESSENTIAL FEATURES OF OPERATIONAL CONTROL INFORMATION SUBSYSTEMS

Blumenthal has defined Operational Control Information Systems as those systems which must exist to support the action and decision subsystems within an organization.[20] The decisions in this instance may be either "programmed" or "non-programmed". Programmed Decisions are those which are repetitive and routine and can be handled by means of a definite procedure when they occur. Non-programmed Decisions are novel and unstructured and there will be no cut and dried method of handling them.[21] It is possible then, to build into Operational Control Information Systems, facilities which will automatically make programmed decisions. In addition the same information systems can produce exception reports in the case of non-programmed decision situations

which will then be examined by management prior to making decisions and taking action. Standard Operational Research Techniques can be built into the information systems to support programmed decision-making routines. For example, the subsystems of LOCIS can be adequately handled by a large number of common inventory control packages which are available. Certain Operational Research Techniques may also be used by management to assist in the decision-making process in the case of non-programmed decisions.

The extent to which the Information Systems within an organization are formally developed will influence the degree to which OR techniques may be routinely incorporated to make programmable decisions. Obviously the more management relies on intuitive (or non-programmable) decision making, the lower the demand for techniques to assist in decision making and the lower the need for formal information systems.

Each of the four main sections of the Total Operational Control System support one or more subsystems. In any organization these subsystems will exist even though they may not be formally defined. Programmable and non-programmable decisions will be made in all organizations, although the relative proportion of non-programmable decisions will increase in organizations with Traditional norms and undeveloped information systems. The greater the degree of routine or programmable decision making, the greater the number of these features that will emerge as individuals or departments positively processing information and taking decisions

accordingly. The potential application of routine Operational Research techniques is directly proportional to the degree to which formal information systems exist and programmable decisions are made. OR/MS techniques however will also be used for assisting decision makers in non-programmable decision situations.

The four main sectors of a typical Total Operational Control system and the subsystems of each sector are as follows:

- Logistics
  - Raw Materials
  - Production
  - Saleable Product
- Physical Assets
  - Facilities and Equipment
  - Capital Projects
- Financial
  - Accounting
  - Finance
- Manpower
  - Payroll
  - Benefits
  - Personnel Administration

Repeat of Fig 3

Now each of these subsystems will consist of certain sections or modules which capture, process, or transmit routine operating information. The actual modules present in any sub-system will be dependent upon the types of business conducted by

the organization. Typical modules for subsystems in each of the four functional sectors are shown in

Table 9 - Physical Assets

Table 10 - Logistics

Table 11 - Financial

Table 12 - Manpower

T A B L E 9

TYPICAL MODULES OF A FORMAL PHYSICAL ASSET OPERATIONAL CONTROL SYSTEM[22]

1. PROPERTY AND EQUIPMENT CONTROL
   - (i) Purchasing
   - (ii) Receiving and Inspection
   - (iii) Stock Control - Asset Register
   - (iv) Distribution Control
   - (v) Maintenance and Repair

2. CAPITAL PROJECTS CONTROL
   - (i) Scheduling
   - (ii) Inspection
   - (iii) Maintenance

T A B L E 10

TYPICAL MODULES OF A FORMAL LOGISTICS OPERATIONAL CONTROL INFORMATION SYSTEM[23]

1. RAW MATERIAL CONTROL
   - (i) Materials Scheduling
   - (ii) Purchasing
   - (iii) Receiving Inspecting Warehousing
   - (iv) Stock Control - Raw Material

2. PRODUCTION CONTROL
   - (i) Materials Requirements
   - (ii) Stock Control - Work in Process
   - (iii) Distribution Control
   - (iv) Production Scheduling
   - (v) Job Control

3. SALEABLE PRODUCT CONTROL
   - (i) Stock Control - Finished Goods
   - (ii) Distribution Control
   - (iii) Sales Control
   - (iv) Order Processing
   - (v) Pricing and Billing (with Accounting Control)

T A B L E 11

TYPICAL MODULES OF A FORMAL FINANCIAL OPERATIONAL CONTROL SYSTEM[24]

1. ACCOUNTING CONTROL
   - (i) Accounts Payable
   - (ii) Accounts Receivable
   - (iii) Salaries and Wages
   - (iv) Stock Control - All Aspects
   - (v) Employee Benefits
   - (vi) Taxes
   - (vii) Labour Distribution Control
   - (viii) Dividends
   - (ix) Pricing and Costing (with Saleable Product)

2. FINANCIAL CONTROL
   - (i) Cash Control
   - (ii) Stockholders
   - (iii) Stock Transfers
   - (iv) Investments
   - (v) Pensions
   - (vi) Insurance

T A B L E 12

TYPICAL MODULES OF A FORMAL MANPOWER OPERATIONAL CONTROL SYSTEM[25]

1. PAYROLL
   - (i) Current Production and Control
   - (ii) Monthly, Quarterly, and Annual Control

2. EMPLOYEE BENEFITS CONTROL

3. PERSONNEL RECORDS CONTROL
   - (i) Inventory Skills
   - (ii) Salary History
   - (iii) General Personnel Data
   - (iv) Training, Planning and Control

These lists are not exhaustive but they do provide some idea of the level to which formal information systems can be implemented. They serve as a useful frame of reference to evaluate to what extent an organization has committed itself to standardized clerical procedures and systems analysis.

There are many management control information modules which will not be found in the tables, as they cannot be considered sufficiently routine to be included. This is generally because

of the number of non-programmable decision situations which are found in the modules.

For example recruiting and employment modules cannot be included in the Manpower Operational Control System although they are linked to Inventory of Skills Module of the Personnel Records Subsystem. Similarly routine Budgeting and Operational Statement production is not included in the Financial System. It could be argued that there are some organizations that have developed their financial and accounting information systems to such an extent that they are routinely projecting Profit and Loss statements and producing management by exception reports, highlighting excessive deviations from budget. This would appear to be more indicative of the sophisticated application of financial modelling techniques than of a routine operating Control Information System.

In a South African environment there are few organizations that are able to carry out this type of financial modelling in-house on a routine basis. In fact the ability to carry out such an exercise would normally indicate that the company had already achieved a high Systems Development Rating. It is unlikely that the decision to introduce a formal OR/MS activity would encounter much resistance within the organization as it is probable that many accepted OR/MS techniques would already be in use.

Derivation of an Information Systems Rating (ISR)

On the basis of the information presented in the Tables (9, 10, 11, 12) an Information System Rating can be derived. This rating will be used to express the level of systems development in an organization. In view of the fact that it is possible to have differing levels of systems development in the same organization, ISR's are expressed individually for each of the four functional systems - PAOCIS, LOCIS, FOCIS, and MOCIS. Subsequently a weighted ISR is calculated for the entire organization using the contributions of the various functional systems.

what about the interdependence? p.125

The basis of the derivation is to decide which of the various modules of the four systems are present in the routine operating information system of the organization. Consider for example, LOCIS or the Logistics Operational Control System, which has three subsystems:

RMOCIS - Raw Material Control
PROCIS - Production Control
SPOCIS - Saleable Product

Now each has various modules which can easily be identified. RMOCIS has four, namely

- Materials Scheduling
- Purchasing
- Receiving, Inspecting, Warehousing
- Stock Control - Raw Materials

In order to achieve a 4 out of 4 rating for RMOCIS, an organization would have to have clearly defined systems designed for data capture, filing, and reporting for all four modules. The information system need not be computerized; in fact it is easier to identify these modules in a manually operated system. In the South African environment several of the modules identified by Blumenthal are not often encountered. For example, the module for Receiving, Inspecting, and Warehousing is usually reduced to an informal inspection by a storekeeper and no records of receipt, inspection and consignment to stores are maintained. As a result most information systems would receive a zero rating for this module.

As far as the other modules are concerned in the South African environment, Materials Scheduling is often neglected; Purchasing Records are usually fairly well developed as they tie in with Creditors/Accounts; Stock Control systems range from highly sophisticated to non-existent. Therefore in a typical South African business one is likely to encounter between one and three of the modules, a rating of four would be exceptional.

The following example will show how the Systems Rating is derived for a Company designated X:

System			ISR	
PAOCIS	Modules observed = 4 Total possible = 8		Rating =	0.50
LOCIS	Modules observed = 10 Total possible = 14		Rating =	0,71
FOCIS	Modules observed = 5 Total possible = 15		Rating =	0,33
MOCIS	Modules observed = 2 Total possible = 7		Rating =	0,28

Taking the LOCIS system, the subsystems consist of RMOCIS which has four modules, PROCIS which has five modules, and SPOCIS which also has five modules. The total number of modules which could be set up formally in a Logistics Operational Control System is therefore 14. In Company X the actual number of modules observed were 10 which gives an Information Systems Rating for LOCIS of 0,71. Ratings for the other three main systems could be similarly derived.

In order to calculate the Overall Information Systems Rating it is necessary to weight each of the individual Systems Ratings by the ratio of the number of modules in the system to the total number of modules which could be encountered in an organization, i.e.

$$\text{Overall ISR} = \sum_{1}^{4} \frac{\text{Max. No. of Modules in System}}{\text{Total No. of Modules}} \times \text{System Rating}$$

The contribution of LOCIS in this example is calculated as:

Maximum number of modules in System = 14

Total Number of modules = (15 + 14 + 8 + 7) = 44

Subsystem Rating = 0,71

$\therefore$ Weighted LOCIS contribution = $\frac{14}{44} \times 0,71$ = 0,22

Hence the overall ISR = $\frac{8}{44} \times 0,50 + \frac{14}{44} \times 0,71 + \frac{15}{44} \times 0,33 + \frac{7}{44} \times 0,28$

= 0,48

On the basis of the calculation shown, Company X has achieved an Overall Information Sybtems Rating of 0,48. This is made up by the contribution of all four main systems.

The highest System Rating encountered in South Africa was 0,93 for a FOCIS system, and the lowest was 0,14 for a MOCIS system. Overall ISR's range from over 0,80 to less than 0,30. Although the list of modules is not exhaustive it is unusual to find South African companies which have developed formal systems, files etc. (either manual or computerized) to support many of the modules. As a result a rating in excess of 0,60 for an individual ISR represents a relatively sophisticated system, whilst an overall ISR in excess of 0 60 indicates a company with a fairly substantial commitment to systems development.

As it happens all ten companies selected for the field studies could be expected to have modules from each of the four main systems - PAOCIS, LOCIS, FOCIS, MOCIS. However, had it

occurred that one of the field studies was conducted in a company lacking the need for a LOCIS subsystem, for example, then the overall ISR would be calculated using the weighting derived on the basis of PAOCIS, FOCIS and MOCIS only.

The ISR for individual systems is a useful indicator of departmental systems development. Consider an organization in which aggressive systems development has only been achieved by one functional area. Comparison of the ISR's will immediately show where this has happened. Furthermore, the development of OR/MS activity in this type of company will often be confined to the functions with high ISR ratings.

CONCLUSIONS

The relationships between OR/MS and various functions such as Data Processing, Systems Analysis, and Management Information Systems were examined in this chapter. The dependence of OR/MS on effective DP and MIS, and the need for intelligent systems design was discussed in the context of Total Systems. Although impractical in most businesses, Totally Integrated Management Information Systems highlight the interdependence of the various functional Information and Control Systems which must exist, formally or informally, in every organization.

In South Africa formal systems design and implementation were neglected by the majority of businesses until 1965 to 1970. However the growth of companies, the rapidly increasing use of

computers, and the need for more accurate operating information has made local companies more aware of the benefits of effective Information and Control Systems, particularly in the areas of Finance and Accounting. At this point in time the level of Systems Development in South Africa varies significantly from company to company. There are often differing levels of systems development within departments of the same organization, due to the absence or presence of managers who have found it advantageous to instal effective systems to control the day-to-day operation of their departments.

The majority of Operational Research techniques require a certain minimum level of data base and systems development in order to be effective. There are still a number of South African companies which have poorly designed information control systems, inadequate files, and little or no computer backup. In these companies decision-making is largely nonprogrammed - i.e. non-repetitive and non-routine and formal job descriptions and responsibility/authority definitions do not exist. Management is Traditional and suspicious or hostile towards innovation. It is extremely difficult for an OR/MS activity to operate in this type of environment. Generally very little historical data is available to test models on, decision-rules for programmable decisions do not exist, and management lacks basic systems-orientation.

For this reason an Information Systems Rating (ISR) has been proposed which is designed to express the level of

Systems Development which exists in an organization. ISR's are specified for the four main functional Operational Control Information Systems - Finance/Accounting, Logistics, Physical Assets, and Manpower. Each individual system contains a number of modules which perform the different operations of the function. An organization must be examined to determine how many of the possible modules are formally defined and supported by files, decision rules etc. An Information Systems Rating will be calculated for each functional Control System based upon the fraction of modules supported.

The Overall Systems Rating is calculated on the basis of the weighted contribution of the four ISR's. The Individual and Overall Systems' ratings give an indication of the receptiveness of an organization to OR/MS. In the field studies that follow these ISR's are correlated with the observed success of ten OR/MS activities in different South African companies.

A low overall ISR would theoretically represent a company in which systems are poorly developed, little or no mechanised data processing is being performed, and management has Traditional norms. In this environment OR/MS activity is unlikely to be formally recognised and will be confined to departments with more modern norms, i.e. with the highest departmental ISR's.

REFERENCES

CHAPTER 5

1 Workshop of Management Science in the Federal Civilian Government, Fredericksburg, Virginia, December 8-11, 1968

2 M. Radnor, and R.D. Neal, "The Progress of Management Science Activities in Large US Industrial Corporation," Journal of the Operations Research Society of America, Vol. 21, No. 2 (1973), p. 445

3 Ibid., p. 443

4 Ibid., p. 434

5 T.R. Prince, Information Systems for Planning and Control (Homewood, Illinois: Richard D. Irwin, 1966), p. 4

6 K.E. Boulding, "General Systems Theory - The Skeleton of Science," Management Science, Vol. II (April 1956), p. 197

7 T.R. Prince, op cit., p. 7

8 Ibid., p. 9

9 Ibid., p. 27

10 Ibid., p. 4

11 S.C. Blumenthal, Management Information Systems, A Framework for Planning and Development (Englewood Cliffs, New Jersey: Prentice Hall, 1969), p. 5

12 R.V. Head, "Management Information Systems, A Critical Appraisal," Datamation, May 1967

13 M. Radnor and R.D. Neal, op cit., p. 428

14 Ibid., p. 443

15 S.C. Blumenthal, op cit., p. 13

16 Ibid., p. 13

17 Ibid., p. 56

18 Ibid., p. 52

19 Ibid., p. 82

20 Ibid., p. 56

21 H.A. Simon, The New Science of Management Decisions (New York: Harper and Row Inc., 1960)

22 S.C. Blumenthal, op cit., p. 57

23 Ibid., p. 76

24 Ibid., p. 57

25 Ibid., pp. 69-71

CHAPTER 6

TOP MANAGEMENT SUPPORT FOR OR/MS ACTIVITY IN SOUTH AFRICA

Top Management Support has been shown to be a key aspect of the OR/MS Diffusion process. However the findings that have been reported in previous chapters are based on American data and it is essential to modify them for South African conditions. A list of factors is presented in this Chapter which Inhibit or Facilitate Top Management Support for Innovation. The degree of influence exerted by each factor is dependent upon the Innovation as well as the economic and business environment of the firm itself. The influence of certain key environmental indicators such as Management Education, EDP support etc. are briefly discussed. On the basis of this information, a forecast is made of the degree of Top Management Support likely to be encountered by OR/MS activity in South Africa in future.

FACTORS INFLUENCING TOP MANAGEMENT SUPPORT FOR INNOVATION IN COUNTRIES OUTSIDE AMERICA

The Diffusion Studies reported in earlier chapters have indicated that Top Management support is one of the most important factors responsible for OR/MS success. This is of course in agreement with the Theory of Authority - Innovation Decision Making where the initial decision to introduce an innovation comes from Top Management. Until the innovation has been genuinely adopted by individuals in subordinate positions it is imperative that it is continually promoted and supported by Top Management.

Research has shown that Top Management attitudes towards innovation are dependent upon the economic and social conditions which prevail in the country concerned.[1] In Underdeveloped countries in which Management has typically Traditional norms, the diffusion of innovation is likely to be a lengthy process, as it becomes a two stage operation. Management has first to become convinced of the need for innovation before the decision to introduce the innovation can be taken. Conversely in countries in which Management has more Modern norms, the duration of the preliminary Management acceptance stage is often very brief.

The Northwestern Research Group has proposed a classification by which countries participating on the Joint Programme for the Diffusion of Management Science are identified as either Small/Underdeveloped or Highly Industrialized. The resulting subdivision of members appears as follows:[2]

Small/Underdeveloped	Highly Industrialized
Columbia	Benelux
India	Canada
Israel	France
Norway	Germany
Venezuela	Italy
South Africa	Japan
	Sweden
	United Kingdom

On the basis of the subdivision certain factors have been identified which appear to facilitate or inhibit Top Management support for innovation.[3] Although two separate lists have been proposed for each subdivision many of the factors are common to both. As far as South Africa is concerned, the composite list appears to be more meaningful than the list applying to Small/Underdeveloped countries on its own.

South Africa, in fact, appears to fall midway between extremes in the Small/Underdeveloped - Highly Industrialized classification. The ranking of South Africa is more clearly shown in terms of the "Fortune 300" listing for 1974.[4] This listing ranks the 300 largest corporations outside America each year. Table 13 gives brief details for each country showing the number of companies included in the listing and the ranking of the largest. The countries are ranked in descending order of the number of companies included in the 300 listing.

The table shows that South Africa and India occupy a transition position in the ranking. Consequently it would appear reasonable to use a composite listing of factors for both Small/

Underdeveloped and Highly Industrialized countries in order to evaluate potential Top Management support for innovation in South Africa.

T A B L E 13

LISTING OF COUNTRIES ACHIEVING MEMBERSHIP OF FORTUNE 300 LISTING FOR 1974

(PARTICIPATING COUNTRIES ON THE DIFFUSION PROGRAMME)

Country	No. of Companies in Listing	Ranking of Largest
Japan	85	5
United Kingdom	55	4
Germany	41	6
France	31	17
Canada	17	74
Sweden	13	69
Italy	8	19
Benelux	5	45
India	2	186
South Africa	2	106
Colombia	-	-
Israel	-	-
Norway	-	-
Venezuela	-	-

The composite listing of factors which have been found to facilitate or inhibit Top Management support for innovation are shown in Table 14. The factors are self explanatory but will be examined individually in subsequent sections where the relative significance of each is assessed in the South African environment.

T A B L E 14

COMPOSITE LIST OF FACTORS AFFECTING TOP MANAGEMENT ATTITUDE TOWARD INNOVATION[5]

INHIBITING FACTORS

1.	TRADITIONAL MANAGEMENT	Owner/Manager, Paternalistic, Conservative, Status Quo, Non-Professional
2.	NON-PROFESSIONAL MANAGEMENT ..	Non-Quantitative Background, No understanding of new Management Techniques
3.	BUSINESS ENVIRONMENT	Stable, Profitable, Relatively Small, Local Monopolistic

FACILITATING FACTORS

1. GOVERNMENT INVOLVEMENT IN ECONOMIC PLANNING
2. INFLUENCE OF INDUSTRIALIZED NATIONS (ESPECIALLY USA) WITH LOCAL SUBSIDIARIES
3. INFLUENCE OF FOREIGN CONSULTANTS
4. INFLUENCE OF TRAINED YOUNG MEN (IN OR/MS)
5. EXPOSURE OF MANAGEMENT TO INNOVATION (SEMINARS, JOURNALS)
6. ADOPTION OF INNOVATION BY COMPETITION
7. INCREASING COMPETITION
8. INTRODUCTION OF COMPUTERS
9. INCREASED SIZE OF FIRMS
10. PRESTIGE ATTACHED TO USE OF NEW TECHNIQUES

In order to consider the importance of each of these factors in South Africa it is first necessary to present a brief description of the South African Business Environment and the History of OR/MS activity/education in this country.

THE SOUTH AFRICAN BUSINESS ENVIRONMENT

Style of Management

The South African economy has always been significantly dependent upon foreign investment particularly in the Mining industry. The country has been reliant upon the Mining sector and particularly the Gold Mining industry for a large proportion of the national product. During the period 1950 to 1970 the Mining industry was faced with static prices and increasing costs. As a result the industry aimed at greater productivity and greater efficiency and used Management Science and Computers as two of the tools to achieve these goals.[6]

Many of the larger South African companies were family owned until the mid 1960's. They were typically stable, highly profitable and by American standards relatively small. In some of these companies management at board level tended to be paternalistic with inadequate professional training. Innovations were often regarded with considerable scepticism.

The years 1965 to 1970 saw significant growth for many South African organizations. During this period a number of groups

of small companies with similar business merged. Managing directors found themselves controlling companies with turnovers five to ten times what they had previously experienced. There were not enough skilled managers who could cope with the problems of increased size and complexity of operation. The growing use of computers and advancing technology placed greater demands upon management at all levels.

As a result the need for more sophisticated Management techniques really began to be felt from 1965 onwards. Until the mid 1960's management was generally not receptive to innovation. The early history of computers (1960-1965) in South Africa is typical of an environment with a deeprooted resistance to change. Since 1965 there have been significant developments in the areas of management training, OR/MS activity, and EDP. These changes have influenced management attitudes towards Innovation. A new generation of managers with more modern norms than their predecessors is emerging.

Size and Performance of South African Organizations

The period 1965 to 1970 was significant for many South African companies as it was a time of merger, acquisition and takeover. However, by American standards, South African organizations are still relatively small. There are exceptions, such as the Mining Houses and several large industrial groups. In the main the turnover and profits of the largest South African companies are very much less than their American counterparts.

For example, consider the group of 108 industrial companies selected by the Northwestern Research team for OR/MS Diffusion Studies. Only four of these companies had turnovers of less than $400 (± R320) million annually.[7]

The Financial Mail Survey of the 100 Top South African Industrial Companies[8] shows that only two would qualify for inclusion in the sample. These are Barlow Rand with a turnover of R586 million and S.A. Breweries with R276 million. Although turnover is not given for each company it appears that only 50 of the 100 companies achieved turnover levels in excess of R50 million.

As far as Profitability is concerned, the Return on Investment and Dividend Yields of the companies in the "Financial Mail 100" are generally better than many of the US companies in the "Fortune 500". It is probably fair to assess the majority of the larger local companies as "Stable" and "Profitable" in terms of the classification of Factors Inhibiting Innovation.

It is difficult to comment on the Monopolistic nature of organizations in the South African environment. It is true that many State controlled operations such as the South African Railways and Harbours, South African Airways, and the General Post Office are monopolies. However very few, if any, of the local quoted or privately held companies are in this position. For example, competition in sectors such as Clothing, Automobiles, Fertilizers, Construction etc. is intense and monopolistic conditions do not exist. There is tariff protection against

imports in various sectors but these vary according to the existing economic situation.

Management Awareness of OR/MS in South Africa

One of the main factors contributing to the lack of Management Awareness of OR/MS in South Africa is the fact that formal establishment of OR/MS activity has taken a great deal longer locally than it did in Britain and the U.S.

Although the first formal Management Science activity in South Africa was created in 1952,[9] it was not until 1968 that the first Operations Research Society meeting was held in Johannesburg. The South African OR Society was founded in November 1969. This event coincided with the first National Conference on Operations Research. The subsequent growth of the Society is shown in Table 15. Membership has doubled over a period which has also been marked by significant growth in other professional societies such as the S.A. Computer Society (the growth of the Society is discussed in a subsequent section in more detail).

The President of the Society made the following comment in his 1973 address to the Society: "... the Society was founded in 1969; 24 years after the end of the war and 17 years later than the Operations Research Society of America. Why this delay?"[10] He believed that the early rigid definitions of what was and was not Operations Research had been largely instrumental in restricting the growth of the discipline.

TABLE 15

MEMBERSHIP OF THE OPERATIONS RESEARCH SOCIETY OF SOUTH AFRICA[11]

(as at 1st November each year)

	1970	1971	1972	1973	1974
Corporate	0	4	4	5	9
Full	74	93	107	120	233
Associate	40	61	68	86	
Total	114	158	179	216	242

One of the most likely reasons for the delayed formation of the Society must be the limited number of formal OR/MS groups that exist in the South African economy. The majority of the early members of the OR Society came from these groups or from universities. As far as can be determined there are less than 40 formally constituted OR groups in the country.[12] Many of these groups, such as those in Iscor, The Chamber of Mines, and the CSIR were formed in the late 1950's.[13]

The limited number of formal OR/MS groups is probably due to the "scale down" effect involved in moving from the American economy to South Africa. Radnor and Neal found that there was a positive relationship between the size of American companies and the presence of formal OR/MS activity.[14]

> The use of OR/MS is very often associated with large scale undertakeings - the likelihood of a company having a formal OR/MS activity will decrease substantially below the Ø400 million level in annual sales.

On this basis there are few South African firms that justify formal OR/MS groups. In fact the nucleus of formal OR/MS activity is concentrated in four main sectors:

State Controlled	8
Oil Companies	5
Banking Sector	4
Mining Houses	5
Commercial/Industry	10
	34[15]

The size of many State Controlled departments would be more than adequate to meet the cutoff level specified by Radnor and Neal. As far as the Oil Companies, Banking Houses, and Mining Houses are concerned, Facilitating Factors can be observed which are sufficiently pronounced to outweigh the implications of the scale-down effect of the South African economy.

The future growth of the OR Society will be tied to the increased understanding of the potential of OR/MS. Many OR techniques such as LP or Pert are employed in South Africa by people who would be surprised to learn that they were using a recognised OR tool. Often these individuals are part of Production Planning or Control groups and the techniques are identified by top management as belonging to the department concerned. Theoretically these are all examples of the Pre-birth stage of the OR/MS Life Cycle, and they may result in the formation of formal OR/MS groups subsequently. Recognised OR/MS techniques

are certainly being used and OR/MS work is being done, but formal Management Science is not receiving credit for it.

In the past it was difficult for South African managers to increase their knowledge and awareness of OR/MS. Some of the companies with formal OR groups run training courses in Management Science but these are not offered to outsiders. This type of course is generally of an introductory nature and is intended to promote the understanding of "OR" within the organization. The actual training of OR analysts is done by providing "on-the-job" experience for individuals who have a degree in Operations Research or who have a sufficiently quantitative background to handle the theory behind the basic techniques.

As OR groups seem to be common to certain sectors of industry - such as banking or oil - the reluctance of the firms concerned to discuss the work they are doing or to offer external courses in OR is understandable. Many of the applications are company confidential in view of the competitive nature of the industries in which OR is prevalent. This means that these organizations tend to maintain a tight control on information regarding their OR applications.

Between 1960 and 1970 most computer manufacturers in South Africa offered limited training in OR/MS but this was essentially sales backup. They ran courses for clients in a particular technique with software packages such as Linear Programming or Critical Path Scheduling. The client identified his

need for a particular technique and approached the computer company, or alternatively the company attempted to introduce a specific package at a current user.

Formal instruction in OR/MS is available through Universities and Master of Business Administration Programmes. However this requires commitment by the manager to an academic course. This is discussed in more detail subsequently. There are no other establishments which give Introductory Courses on Operations Research.[16] The Johannesburg and Cape Town Technical Colleges have both tried to do this as part of their Advanced Technical Education programmes in the past. In view of the lack of response the courses have been cancelled and are unlikely to be repeated until a definite demand is observed. None of the Management Consultants operating in South Africa offer instruction courses other than in specifics, such as Stock Control. They believe that there is no demand for OR/MS courses due to a lack of interest in the subject.

There is a general belief that the mathematical nature of the subject has a great deal to do with the apparent lack of interest. The manager of a Cape Town computer bureau which had tried to offer a course in OR said "most middle managers lack confidence in being able to handle the mathematics and shy away from the course."[17] In Business Schools OR/MS courses are orientated more towards providing an appreciation of areas of application. An analyst with a formal OR training is still required to implement projects.

A survey carried out on OR/MS education in South Africa in 1974 detected a surprising lack of communication between the various bodies involved in the education process.[18] There did not appear to be any clearly defined goal in the teaching programmes at Universities. There was little attempt on the part of the universities to find out whether OR graduates being produced were suited to the requirements of industry.

During the past four years there does seem to be an increasing understanding of OR/MS and a general improvement in attitude of top management towards innovation in general and OR/MS in particular.

This is partially due to the increasing number of South African managers who annually attend Management Development Programmes or Advanced Management Programmes locally or in America. Although many of the local courses are too short to include OR/MS topics they do introduce concepts of model building and model manipulation in Finance and Business Simulation. There has been a significant increase in the number of Business Schools offering these courses and the number of courses offered during the past five years. In a country the size of South Africa this trend can have a dramatic effect on the attitudes of top management throughout the country in a very short space of time.

As a result managers are becoming more aware of the role that Scientific Management can play in their businesses. In addition inflation, competition and reduced profits are making

managers examine their operations more thoughtfully. It is inevitable that the demand for competent OR analysts and other business specialists will increase in this environment.

Management Science Education in South Africa[19]

Although it was shown in Chapter 2 that trained OR/MS specialists do not make the best personnel for recruitment into OR/MS activities, it is nevertheless important to evaluate the sources of formal OR/MS education in South Africa. Graduates from these programmes will assist in increasing the level of awareness of OR/MS amongst Top Management in this country.

South African universities started to give lectures on OR techniques such as Linear Programming and Scheduling in 1965-1968. These subjects were introduced in graduate courses in Mathematics, Statistics and Engineering but were not always identified as Operations Research. The University of South Africa was the first university to offer a degree course in Operations Research in 1967 and the University of Stellenbosch followed soon after. By 1974 all eight of the major universities were offering formal courses in Operations Research, often in more than one faculty and generally at post graduate level.

As a consequence of the emergence of OR from the mathematical faculties the courses are highly quantitative and to a large degree theoretical. Only three of the eight universities offer courses at undergraduate level at the moment. The

majority of courses are at Honours as well as Masters and Doctorate levels.

In addition to these intensive formal Operations Research courses at Universities there are also courses included in the curricula of most South African Business Schools. Generally courses are of an introductory nature where OR/MS techniques are handled in broad outline. However most Business Schools do offer elective courses in Management Science which permit those students with the aptitude and ability to study OR techniques in greater depth.

Apart from these two sources there are very few bodies that provide formal education in Operations Research. Probably the most important source of OR/MS education in South Africa at present, other than the Universities or Business Schools, is through the local computer bureaux and computer manufacturers. In order to appreciate the implications of this trend it is important to have an understanding of the history of EDP in South Africa.

The Introduction of Computers into South African Business

The introduction of computers into South African business began in the mid-1950's. Problems of personnel, inadequate backup, and internal resistance to computers resulted in a number of unsuccessful installations. Stories of disaster made

many would-be users extremely cautious and the growth of the industry was erratic. Table 16 shows the number of computer installations in South Africa between 1958 and 1969.

T A B L E 16

NUMBER OF COMPUTER INSTALLATIONS IN SOUTH AFRICA[20]

Year	No. of Computers
1958	3
1960	9
1962	28
1964	62
1966	132
1968	270
1969	350

The estimated investment in computers in South Africa in 1969 was R84 million.[21] The number of computers had increased to over 600 by September 1972 and investment had more than doubled to reach R218 million.[22] Projections of investment in computers give a value for 1980 of R1 000 million based upon an observed compounded annual growth rate of 22 per cent.

More recent data is not available at present but a recent survey of five major computer companies in South Africa produced some interesting figures relating to the numbers of computers actually sold and the number in operation during the period 1970-1974.

TABLE 17

COMPUTERS INSTALLED AND COMPUTERS SOLD BY FIVE MAJOR SUPPLIERS IN SOUTH AFRICA 1970-1974[23]

Year	Computers Sold		Computer Installations	
	No.	% Increase	No.	% Increase
1970	122	-	302	-
1971	137	12,3	419	38,7
1972	173	26,2	574	37,0
1973	262	51,4	672	32,8
1974*	327	25,0	922	21,0

*Estimate at October 1974

It is not possible to reconcile the two sets of figures for two reasons. Companies may 'upgrade' their equipment i.e. replace a third generation machine by a fourth generation machine, or an existing customer may change to another manufacturer not in the sample. The significant increase in machines sold in 1973 was probably due to existing users upgrading from third to fourth generation equipment.

Perhaps the most interesting aspect of the information in the table is the 300 per cent increase in the number of users between 1970 and 1974. In a country the size of South Africa the implications of this increase are considerable.

The typical applications software supplied with fourth generation machines would provide these users with the facility to carry out sophisticated Management Science and Management

Information Systems applications. This would dramatically improve the available facilities for OR/MS activities. Even more interesting is the significant buildup in demand for trained EDP personnel that would accompany the growth in the number of computer installations.

This increased demand for trained personnel is reflected in the membership figures of the South African Computer Society. The Society was established in 1955 and by 1968 membership had risen to 456, an average of less than 40 new members per year. Between 1968 and 1973 membership increased at an average rate of 136 per year and between July 1973 and July 1974 it increased by 238 to a current total of 1 373.[24] This increase has been in the face of high membership standards introduced by the Society. The aim of the Society is to achieve local recognition amongst South African businesses and to ensure that standards of education and competence of members are uniformly high.

The introduction of fourth generation equipment, particularly multi-programming and terminal systems, has had a significant effect on the applications for which computers are being used. An article by Feldberg in 1969 commented "In spite of the growth of installations, the major areas in which commercial computers are presently being used is in control of production processes, stock inventory and machine minding."[25] Four years later "Management Magazine" published an article listing the major installations in the Republic and the applications which were running or planned on each installation.[26] The article

showed that applications had changed dramatically whilst proposed applications were even more sophisticated. Table 18 lists the breakdown of applications on a percentage basis in over four hundred installation. The accent on stock and production control is still evident but the emphasis of application has moved to Accounting and Financial procedures.

TABLE 18

BREAKDOWN OF APPLICATIONS CURRENTLY RUNNING ON SOUTH AFRICAN COMPUTER INSTALLATIONS[27]

	%
Debtors, Creditors, Salaries Wages	44,9
Other Accounting Functions	22,1
Stock Analysis and Control	13,8
Financial Budgeting and Reporting	6,8
Sales Analysis and Control	6,8
Production Statistics and Control	3,6
Other	2,0
	100,0

Due to the variety of proposed applications it is impossible to produce a similar listing showing a profile of future applications. However two general observations can be made about the type of work that is likely to be computerized in South Africa in the next few years. Companies will be using terminals to improve their decision making in the areas of sales accounting and stock control; in addition a number of companies

are planning to carry out more sophisticated forecasting and planning using data banks and forecasting software. Both developments denote a trend to increased integration of existing applications as well as improved design of Management Information and Control Systems. This trend will make significant demands on Management Science skills in South Africa.

The Relationship between OR/MS and Computers in South Africa

The interdependence of OR/MS and DP/MIS in America has been stressed in previous chapters. Radnor and Bean identified the availability of computer support as a significant facilitating factor influencing top management support for innovation. The relationship of OR/MS and Computers in South Africa goes back a long way. In fact, computer manufacturers were promoting OR/MS applications packages in South Africa four or five years before the South African OR Society was formed.

Probably the first and most widely marketed OR/MS application package was IBM's inventory control system IMPACT which was introduced to South Africa in the early 1960's. This system was backed by two and three week customer appreciation courses, as well as considerable promotional activity. ICL and Burrouhgs followed this up with similar suites of programmes relating to inventory and production control. Critical Path and Pert programmes began to be marketed in the mid-1960's by virtually all the major computer companies in the Republic. Certain computer bureaux established a reputation for running CPM and Pert

packages and provided a limited amount of customer education. Generally the emphasis was on the development of the application by the user who would then approach the bureau to instal the package.

OR/MS applications software have become standard packages for nearly all manufacturers and bureaux in South Africa. However they normally are marketed as separate packages for specific purposes and are not promoted as part of an overall Management Science programme. During the last two years however three companies have started to promote OR/MS activities far more aggressively than before. Computer Sciences Sigma Limited have actively pursued the Management Science applications market by providing both the software and the expertise to enable clients to implement OR techniques. This marketing effort has been extremely successful, although costly, and CSSL currently report at least 50 regular users who can be said to be employing sophisticated Operational Research techniques such as modelling. CSSL have concentrated on the development of the computer time-sharing market in the Republic and this has been responsible for a great deal of the OR/MS success.

IBM launched "Call 360" in 1972. This is a time-sharing network offering packaged systems in the following areas:

1. Business and Finance, including
   - A General Accounting Package
   - MINIMIS, An Information Retrieval System

2. Civil Engineering
3. Electrical and Electronic Engineering
4. Management Science Packages
5. Mathematics
6. Mechanical Engineering
7. Simulation
8. Statistics

Amongst the programmes included in Section 4 - the Management Science Package - are the following:

- Discounted Cash Flow Programmes
- General Purpose Forecasting Programmes
- LP Packages
- Transportation Package
- Project Network Analysis
- Corporate Modelling and Financial Planning (STRATPLAN)
- General Purpose Statistical Package
- Business Games Packages

IBM report that they have been very favourably impressed by the response to the Call 360 Service, particularly with respect to STRATPLAN which is a Financial Forecasting and Modelling package. As it is possible to have access to other modules of the Call 360 suite of programmes whilst running STRATPLAN (for example the Statistics package) the analyst can carry out a number of manipulations on the same model.

Although IBM admit that most of the Call 360 applications to date have been Management Science they are not promoting Call 360 as a purely Management Science facility. The company provides adequate documentation for each of the application packages, but at this moment in time it would appear that the "hard-sell" is via STRATPLAN.

ICL have met with similar success with PROSPER which is also a Financial Forecasting and Modelling package, initially it was not suitable for time sharing applications. There are PROSPER users in most of the major centres and ICL have appointed a full-time Operations Research manager to promote the application of PROSPER and other OR packages with existing clients and to develop new customers through the ICL Bureaux network.

These developments have occurred during the last five years and it is too early to estimate the effect they will have on management attitudes towards OR/MS activities in South African companies. However it is inevitable that the increase in OR/MS expertise within computer marketing organizations as well as the promotion of OR/MS applications by these organizations will result in an increased awareness of the potential of OR/MS techniques amongst users.

Systems Development in South Africa

The disaster stories about unsuccessful computer installations in the Republic during the period 1955 to 1965 generally indicated that companies had attempted computerization without

paying sufficient attention to systems development. The growth of the computer industry was slow and unhappy during this time. The situation improved between 1965 and 1970 and the number of computer installations increased significantly.

By 1974 two-thirds of the computer applications in South Africa were in the areas of Accounting and Finance (FOCIS).[28] Processing of Debtors, Creditors, Salaries and Wages has become sufficiently commonplace to regard manual processing as the exception rather than the rule. Some firms are carrying out sophisticated financial applications such as budgeting and long range planning. "Management Magazine" carried out a survey of the top 100 South African companies in 1974 and found that 77 of these companies had formal Long Range Planning Groups.[29] Of these companies 37 per cent used computer processing, 38 per cent used simulation of some kind, and 50 per cent employed Operations Research techniques. More than half of the companies only started doing formal Long Range Planning after 1969. These developments all point to improved systems development in the South African environment.

Prior to 1965 overambitious computerization projects using the input from a number of weakly developed manual accounting systems were either abandoned after two or three years of trial and error or were left partially implemented due to insurmountable systems development problems.[30,31] Many of the difficulties that beset these early installations stemmed from staff shortages, bad training and inadequate backup. However the

greatest difficulties arose from attempts to computerize weak manual systems. During the early 1960's management appeared to believe that the acquisition of a computer gave the user the ability to produce sophisticated management information at the flick of a switch. It took ten years and a great deal of money to show that successful installations had to be founded on efficient systems.

Many South African companies have started the change to computers via a bureau of installation. The 50-odd computer bureaux in the country generally specialize in standard packages such as wages, creditors, and debtors. Firms find this a less traumatic and far less expensive way of ascertaining to what extent their systems are suitable for computerization. The experience gained as a result of this approach is often adequate to ensure a fairly trouble free changeover to an in-house installation.

The awareness of systems inadequacies has had its effect on the computer manufacturers themselves. An area manager of one of the larger houses made this clear recently.

> Previously we were willing to sell a computer to anyone, even though we were well aware that it would be years before anything worthwile was running on the machine. This policy backfired as we were inevitably blamed, never the purchaser. Frankly we do not have the time or staff to clear up these messes any longer. Now, if we are worried about the state of a client's information systems we recommend that he approach a reputable consultant and ask for his opinion prior to purchase.[32]

This trend is reflected in the increasing number of auditing firms that are offering their clients guidance in the areas of information systems and computers. Firms such as Cooper Brothers, Arthur Andersen, Price Waterhouse have established management consulting divisions for the purpose of assisting their clients improve their existing accounting and financial reporting systems. These groups have been existence for the last five years and are currently being expanded by the introduction of men with data processing expertise. One firm of management consultants, McCaul and Associates, has been established specifically to improve accounting and costing information. McCaul's stress the benefits of computerized information systems for improved decision-making facilities.

These changes took place over a period that has seen rapid growth in the number of local commercial computer installations. It is probably more accurate to say that the rapid growth in the number of computer installations has been due to the significant improvement in standard operating systems - particularly in Financial Operating Control Systems - in the Republic. Stories of unsuccessful installations are being forgotten and are being replaced by stories about new and exciting systems which have been successfully installed. A local computer supplier and a user recently introduced a real-time inventory control and forecasting system which is reportedly as sophisticated as any similar system in America or Britain. The entire application was designed, programmed, and implemented in South Africa and has reduced annual stock holding costs by about

R120 000 for a total investment of R200 000.[33]

The Influence of Overseas Expertise on OR/MS in South Africa

The list of Facilitating Factors shows that the availability of Overseas expertise can have a significant effect in influencing Top Management support of Innovation. Four factors appear to be involved:

- Influence of Industrial Nations with Local Subsidiaries
- Influence of Foreign Consultants
- Exposure of Management to Innovation
- Adoption of Innovation by Competition

These factors are responsible for the majority of the formal OR/MS groups operating in South Africa as well as many OR/MS activities which are not formally recognised. It will be recalled that out of a total of 34 OR/MS groups, 5 were located in Oil Companies, 4 in Banking, 5 in Mining, and 10 in commerce and industry. Closer examination shows that 19 of these 24 groups are found in companies with strong international affiliations.

OR/MS group leaders in these companies often received their training with parent OR/MS groups located in Head Office in Europe, Britain or America. Local OR/MS personnel are seconded to parent companies and there is a regular interchange of international staff. Many of the OR/MS groups were initially staffed by members of the parent company until local expertise became available. This accessible expertise has made it fairly easy

for local subsidiaries of multinational corporations to develop faster than purely South African based concerns. A recent study has confirmed that South African companies with overseas affiliations were more advanced in the use of planning techniques than purely South African based companies.[34]

Top Management support for OR/MS in a situation where it is quite simple to obtain assistance in the staffing of OR/MS groups and the design and implementation of projects must be greater than it would be in the case of companies which have to start from scratch. In addition support for OR/MS in a multinational subsidiary is often written into Job Descriptions and Responsibilities of Senior Executives. Many local organization structures are mirror images of similar structures all over the world and the OR/MS group is part and parcel of the organization structure. The activities of the OR/MS group are described in detailed operating procedure specifications and as a result have to be performed in order to provide routine operating information for the International Head Office.

In South Africa the fact that three distinct sectors of commerce are found to have established OR/MS groups is partially due to the competitive nature of the sectors involved. Once an OR/MS group was established by one company in a particular sector it was inevitable that other members of the sector would be forced to follow the example. The fact that all the companies concerned are subsidiaries of multinational corporations with formal OR/MS groups made Top Management Support more easily obtained.

Formal OR/MS groups, as well as OR/MS activities, are often generated as a result of the visit of overseas consultants to South Africa for specific projects. Although few international consulting firms have permanent offices in this country, a number (such as Arthur D. Little and McKinsey) have completed major OR/MS assignments here during the last ten years. Permanent OR/MS activities have often been established as a result of these assignments staffed by local personnel.

Theoretically it is feasible for both local organizations, as well as local subsidiaries of international corporations, to employ international consultants. In practice it is more likely that these firms would be employed by the subsidiaries rather than the locally controlled businesses. There are three reasons for this. The first two relate specifically to the use of management consultants and the third relates more to the attitudes of management in multinational corportions. The visit of consultants to South Africa is often as a result of an overall programme conceived and co-ordinated from abroad, the local subsidiary is merely informed that consultants are being employed. It is also easier for local subsidiaries to obtain information regarding specialized OR/MS consultants than it is for local companies with no overseas contacts.

Finally, it is inevitable that Top Management of local subsidiaries of multinational corporations will be more favourably disposed towards innovative activities than their local counterparts. Innovations such as Management Consultants, OR/MS,

EDP etc. will be far more familiar to these individuals than they would be to managers who have only experienced local situations. This is mainly due to the continual movement of Top Management in multinational corporations which makes them more aware of developments in management practice, less apprehensive of the consequences of change, and more change orientated.

CONCLUSION

Top Management support for OR/MS has been found to significantly influence the successful diffusion of Management Science in American Business. It appears to be one of the most important criteria in the OR/MS diffusion process. In the context of Authority-Innovation Decision Situations Top Management support can be broken into two distinct phases.

The first phase relates to the decision by management to officially sanction the formal introduction of OR/MS activity in an organization. Here Top Management as a group are acting collectively as a Change Agent. This decision constitutes the action by which OR/MS activity moves from the Pre-Birth to Introductory Stages of the Life Cycle. At this point Top Management requires that individuals in the organization adopt the OR/MS activity.

The second phase of Top Management support describes the persistent attempts to ensure that OR/MS is permanently adopted by individuals at all levels within the organization and

and becomes a permanent part of the organization structure. This phase is an action phase as it involves counselling, sponsorship and the provision of financial and personnel backup to establish the new activity. During this phase OR/MS moves from the Introductory Stage of the Life Cycle to the Transitional or Maturity Stages. This phase has already been described in some detail in Chapter 4 of this thesis.

Various factors have been found to influence Top Management support for Innovative activity during the first of Decision-Making phase of the Authority-Innovation Decision process. A composite list of these factors is presented in this chapter. The weighted effect of each factor in a particular country is dependent upon the nature of the innovation and prevailing economic and social conditions in that country. In order to establish the importance of the various factors as far as the introduction of OR/MS in South African business is concerned, it is necessary to assess the state of Management Awareness, OR/MS education, EDP expertise etc. On the basis of this Technical Scenario it is possible to decide which are the critical Inhibiting and Facilitating factors which influence Top Management support for OR/MS activity in South Africa at present.

Inhibiting Factors

1. Management Style

- Traditional Management

The last ten years (1965-1975) have seen the beginning of a change to professionally trained managers with modern norms. The rapid growth of business, and the emergence of conglomerates has forced owner-managers to hire professional managers and to become more professional themselves. The conservative status-quo manager with non-professional training has had to adapt his changed environment to survive. Many managers have attended Management Training programmes locally or abroad. They have come into increasing contact with professional trained managers and management specialists. They are beginning to be aware of the possible benefits of OR/MS.

- Non-Professional Management

Managers with non-quantitative backgrounds or with an inadequate understanding of new management techniques have become aware of the potential of innovative activities such as DP and OR/MS. They have been forced to be more receptive towards modern management techniques, and their attitudes towards business graduates have changed dramatically during the past ten years. The antagonistic managers of the 1965-1970 period have become far more receptive to the ideas and objectives of MBA's during 1971-1974. One of the most significant signs of this

change have been a marked reduction in the job mobility exhibited by the early MBA's.

2. Business Environment

The number of Relatively Small Firms has decreased during the past ten years. Rapid turnover, growth and a tendency to grow by acquisition has changed the profile of South African business. Although business has remained stable and profitable, an acute shortage of skilled labour and rapid inflation has taxed existing management skills, and has forced management to recruit professional managers. Local firms are still too small (turnover less than R320 m. annually) to justify formal OR/MS groups, and many OR/MS activities exist without being recognised as such.

Facilitating Factors

The effect of Government Involvement in Economic Planning has not been as marked as the indirect effect of the use of OR/MS activities by the Government. Planning groups in ISCOR, the SAR and H have been responsible for much of the innovative work done in the Republic during the last five years.

The influence of industrial nations with local subsidiaries (especially the USA) has been significant. The majority of recognised OR groups in South African industry exist in companies which are able to draw expertise from abroad. Management in these companies is probably more supportive towards innovation due to their international experience.

The influence of foreign consultants has perhaps not been a significant facilitating factor. However some OR/MS activities have been established in local firms by companies such as Arthur D. Little and McKinsey. Generally the impact of foreign consultants is more marked in subsidiaries of international firms which are already orientated towards innovation.

Probably the most important facilitating factor during the last ten years has been the increasing number of young men trained in modern management (rather than OR/MS) techniques. Assimilation of these individuals has meant that Top Management has had to become more receptive to new ideas and new techniques. This assimilation process has been facilitated by the greater exposure of established management to innovation through seminars and journals. This change can be observed in the increased attendance at top level management programmes and the increased membership of bodies such as the Computer Society, the Organization and Methods Society, the Institute of Personnel Management.

Competitive activity in the area of EDP has had a significant effect on the development of systems and the improvement of accounting and financial controls. However the adoption of OR/MS by Competition does not seem to be a significant facilitating factor. This may be due to the secrecy that surrounds the development of OR/MS techniques in the South African environment. Much of the work being done is not publicized in any way, and as a result does not reach the ears of Top Management.

The introduction of computers which has been accelerated dramatically during the past five years has made Management particularly receptive to innovation. The growing use of computers to carry out OR/MS applications such as Modelling and Forecasting could increase the number of formal OR/MS activities in the next five years and increase the demand for OR/MS expertise. This trend is emphasized by increased competition and the increased size of firms which has made problems of management and decision making far more acute than they were previously. The reduced profitability of companies, inflation, and a shortage of skilled clerical labour can only emphasize the need for more sophisticated planning techniques and improved information systems.

The final factor which relates to the prestige attached to the use of new techniques no longer appears to be significant in the South African environment. Whilst it is true that many of the computers installed during 1955-1965 were as a result of prestige consideration, the increased professionalism of South African managers is rapidly reducing the considerations of prestige.

It is possible to conclude that the period 1965 to 1975 has seen the beginning of the decline of many of the factors that have inhibited Top Management support for OR/MS activity in South Africa in the past. At the same time the majority of the factors that favour Top Management support have emerged. Although managers with Traditional norms still exist; the influence of factors such as the current economic climate, the increased number of trained managers, and the improved effectiveness of computers will produce

an environment with increased Top Management support for OR/MS activities. As a result there will be a greater demand for OR/MS analysts and a greater application of OR/MS techniques. Inevitably this will result in an increase in the number of formal OR/MS groups in South Africa.

REFERENCES

CHAPTER 6

1 M. Radnor and A.S. Bean, "Top Management Support for Management Science," Omega, Vol. 2, No. 1 (1974), pp. 72-73

2 Ibid., p. 75

3 Ibid., p. 75

4 H.E. Meyer, "The Fortune Directory of the 300 Largest Industrial Corporations Outside the US," Fortune, August 1974, pp. 174-187

5 M. Radnor and A.S. Bean, op cit., p. 75

6 M. Feldberg, "Summary of the Place of the Management Sciences in South Africa," Paper delivered to the Fifth Meeting of the International Federation of Operations Research Societies, Venice, Italy, June 1969, p. 6

7 M. Radnor and R.D. Neal, "The Progress of Management Science Activities in Large US Industrial Corporations," Journal of Operations Research Society of America, Vol. 21, No. 2 (1973), pp. 427-450

8 ---- "Top Companies," Financial Mail Special Survey, May 24, 1974, pp. 41-47

9 D.D. Masterson, Presidential Address to the Operations Research Society of South Africa, Annual Conference 1972

10 A.J. Rudolph, Presidential Address to the South African Operations Research Society, 22-23 November 1973, p. 1.

11 Personal Communication from the Secretary of the Operations Research Society of South Africa, 9th August 1974

12 G.J. Butler, M.J. Bisset et al, "Applications of Operations Research," Unpublished Student Project, Graduate School of Business, University of Cape Town, July 1974

13 D.D. Masterson, op cit.

14 M. Radnor and R.D. Neal, op cit., p. 429

15 G.J. Butler, M.J. Bisset et al, op cit., p. 3

16 C.M. Moore, J.P. Hughes et al, "The Scope of Educational Opportunities in Operations Research in South Africa," Unpublished Student Project, Graduate School of Business, University of Cape Town, July 1974, p. 2

17 Personal communication with Mr. M. Morris, Managing Director, ASAP Computer Bureau, December 1973

18 C.M. Moore, J.P. Hughes et al, op cit., p. 12

19 Ibid.

20 M. Feldberg, op cit., p. 11

21 ----- "Declassified Information," Management Magazine, April 1973, pp. 55-56

22 Ibid., pp. 55-56

23 D.S. Wright, "Survey of Five South African Computer Manufacturers," Unpublished Research Paper, December 1974

24 Personal Communication with Mr. A.O. Bischoff, President of the S.A. Computer Society, 4th July 1974

25 M. Feldberg, op cit., p. 4

26 ----- "Computers, Who's Got What," Management Magazine, December 1973, pp. 57-70

27 Ibid., p. 60

28 Ibid., p. 60

29 ----- "What Long Range Planning has done for the Top 100 Companies," Management Magazine, May 1974, pp. 39-46

30 C. Bird, J. Dew et al, "Evaluation of a Computer System at Company X," Unpublished Student Project, Graduate School of Business, University of Cape Town, July 1972

31 G.J. Butler, M.J. Bisset et al, op cit., p. 4

32 D.S. Wright, op cit., p. 8

33 Address by Mr. W. Couger of Burroughs Computers to Students at the Graduate School of Business, November 1974

34 ----- "What Long Range Planning has done for the Top 100 Companies," op cit.

CHAPTER 7

A MODEL OF THE DIFFUSION OF OR/MS IN SOUTH AFRICAN BUSINESS

It is now possible to propose a preliminary model of the diffusion process of OR/MS activity in South Africa on the basis of material presented in previous chapters of this thesis. The model includes factors which have been found to influence the diffusion of OR/MS in countries involved in the "Diffusion of OR/MS" project. It is hypothesised that in South Africa the diffusion of OR/MS follows a distinct two stage process. The Primary Diffusion Process corresponds to the involvement of Top Management prior to the Authority-Innovation Decision stage. The Secondary Diffusion Process deals with the diffusion of OR/MS throughout the organization once the Authority-Innovation Decision has been taken.

The field studies which are reported in a subsequent chapter are used to examine the relative importance of various internal and environmental factors which are believed to influence the Primary and Secondary Diffusion Processes. The factors are identified in this chapter and are categorised either as "controlling" or "assisting" depending upon their anticipated level of importance. These categories are based upon the demonstrated importance of the various factors in American and International studies weighted by considerations relating to the local environment.

AUTHORITY-INNOVATION DECISION PROCESSES AND THE OR/MS LIFE CYCLE

This thesis is concerned with the manner in which an innovation, OR/MS activity, is likely to diffuse into a South African business. It will be recalled that Diffusion describes the process by which an individual (or group) decides to adopt or reject an innovation after passing through stages of Awareness, Interest, Evaluation and Trial. The diffusion of OR/MS into a business is an example of a particularly complex diffusion process normally referred to as Authority-Innovation Decision Diffusion.

Authority-Innovation processes are characterised by a decision on the part of the Top Management of an organization to adopt an innovation. Once this decision has been taken, subordinate personnel in the organization are forced to use the innovation. Although subordinates may appear to adopt the innovation as ordered, their attitude may disguise a fundamental rejection. The relations between an OR/MS group and the remainder of an organisation are traditionally of such a nature that it is possible for subordinates in the organization to destroy the group whilst appearing to act in accordance with Top Management instructions.

It is hypothesised that Authority-Innovation Decision processes are in fact two diffusion processes superimposed upon one another. The Primary Process is one in which Top Management passes through the stages of Awareness, Interest, and Evaluation. Awareness may occur as a result of informal OR/MS activity within the organization or as a result of environmental influences. The

Primary Process may end if Management decides to reject OR/MS. In this case there is no Secondary Process.

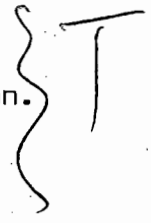
The Secondary Process begins as soon as Top Management orders a Trial of OR/MS. Prior to this the entire Diffusion process has centered around the attitude of Top Management towards OR/MS. As soon as the Trial starts certain subordinates involved in the Trial go through the phases of Awareness, Interest, and Evaluation. They may decide to genuinely adopt OR/MS in which case the Trial has a better chance of success than it has if subordinates reject OR/MS. Apart from the attitudes of subordinates there are a large number of other factors which will contribute to the success or failure of the Trial.

The Secondary Process can therefore end in a number of ways. If the Trial is a failure Top Management may reject OR/MS entirely. In this case the Secondary Process is complete and subordinates in the organization will not be involved in any further OR/MS activities. Top Management may order a further Trial if the first is a failure, and the Secondary Process will continue.

If the Trial is a success Top Management may make the Authority-Innovation Decision to adopt OR/MS and to introduce it formally into the organization. Subordinates are now required to adopt OR/MS as a permanent facet of the company. Over a period of time an increasing number of subordinates in the organization will be exposed to OR/MS activities. As a result of the exposure they

will pass from Awareness to Trial followed by genuine Adoption or Rejection, which may be disguised or obvious. It is often necessary for subordinates to feign adoption until circumstances cause Top Management to discontinue their adoption of OR/MS. Discontinuation is only likely to occur if the OR/MS group carries out a number of unsuccessful projects.

The Secondary Process can therefore be completed in two additional ways. A series of successful OR/MS projects may influence subordinates to adopt OR/MS, and the OR/MS activity will then be genuinely adopted by all levels within the organization. Alternatively, continued failure may eventually force Top Management to change its attitude and discontinue the innovation. In both cases the Secondary Process is complete.



Primary and Secondary Process and the OR/MS Life Cycle

The OR/MS Life Cycle proposed by Radnor and Rubenstein can be aligned with the Primary and Secondary Process based on the diffusion model of Rogers and Shoemaker. The OR/MS Life Cycle, which was discussed in Chapter 4, consists of four phases - Pre-birth, Introductory, Transitional, and Maturity. Any of the four phases can be followed by Death which is the final phase.

The Primary Process in Authority-Innovation Decisions on Diffusion corresponds to the Prebirth Phase of the Life Cycle. Rejection, i.e. Death, will be as a result of Top Management's decision not to put the innovation to test and the OR/MS activity

will not proceed to the Introductory Phase. The Primary Process will be complete at this point. The Secondary Process begins as soon as Top Management decides to run a Trial on OR/MS and starts to allocate resources to the activity, i.e. the Introductory Phase. Discussion in Chapter 4 indicated that if the Trial period in the Introductory Phase is successful, OR/MS will move to the Transitional and Maturity Phases of the Life Cycle. The Secondary Process is complete in the Maturity Phase. It must be remembered that the Life Cycle can be terminated by Death even in the Maturity Phase and consequently OR/MS can be rejected even though the Secondary Process is complete. The chances of this happening are slight. If the OR/MS activity is unsuccessful in the Trial period it may be rejected by Top Management and will enter the Death Phase. In this case, the Death Phase of the Life Cycle represents the end of the Secondary Process.

The Primary Process of Authority-Innovation Decisions on OR/MS is therefore concerned with the attitudes of Top Management toward innovation. The Secondary Process is more concerned with the factors which influence OR/MS success. In a highly industrialized society with advanced technology, such as the US, Top Management is regularly exposed to innovation. This will be especially true in any company appearing in the Fortune 500 listing, as was the case with the majority of companies in the Northwestern sample. In this type of company the problems involved in the Secondary Process must far outweight the problems of the Primary Process. Earlier chapters have shown that Top Management Awareness and Support for OR/MS in America has increased significantly during

the last ten years. As a result American studies of OR/MS diffusion have tended to concentrate on those factors which influence OR/MS success - i.e. once OR/MS has been adopted by Top Management and the Secondary Process has started.

In countries outside the US and particularly in less industrialized countries, Top Management is less exposed to Innovation. The Primary Process in Authority-Innovation Decisions will become increasingly important where the Norms of Top Management are more Traditional. As a result the Primary Process tends to become the ruling process in OR/MS diffusion situations as Top Management's exposure to innovation decreases. The probability of Rejection during the Primary Process will increase. In South Africa it is critical to produce a diffusion model which adequately stresses the importance of the Primary Process.

The factors which have been found to influence Top Management's attitude towards Innovation were described in Chapter 6. A number of these factors are believed to play a part in the Primary Process in South Africa. Some may be of minor importance whilst others will be fundamental to the diffusion of OR/MS.

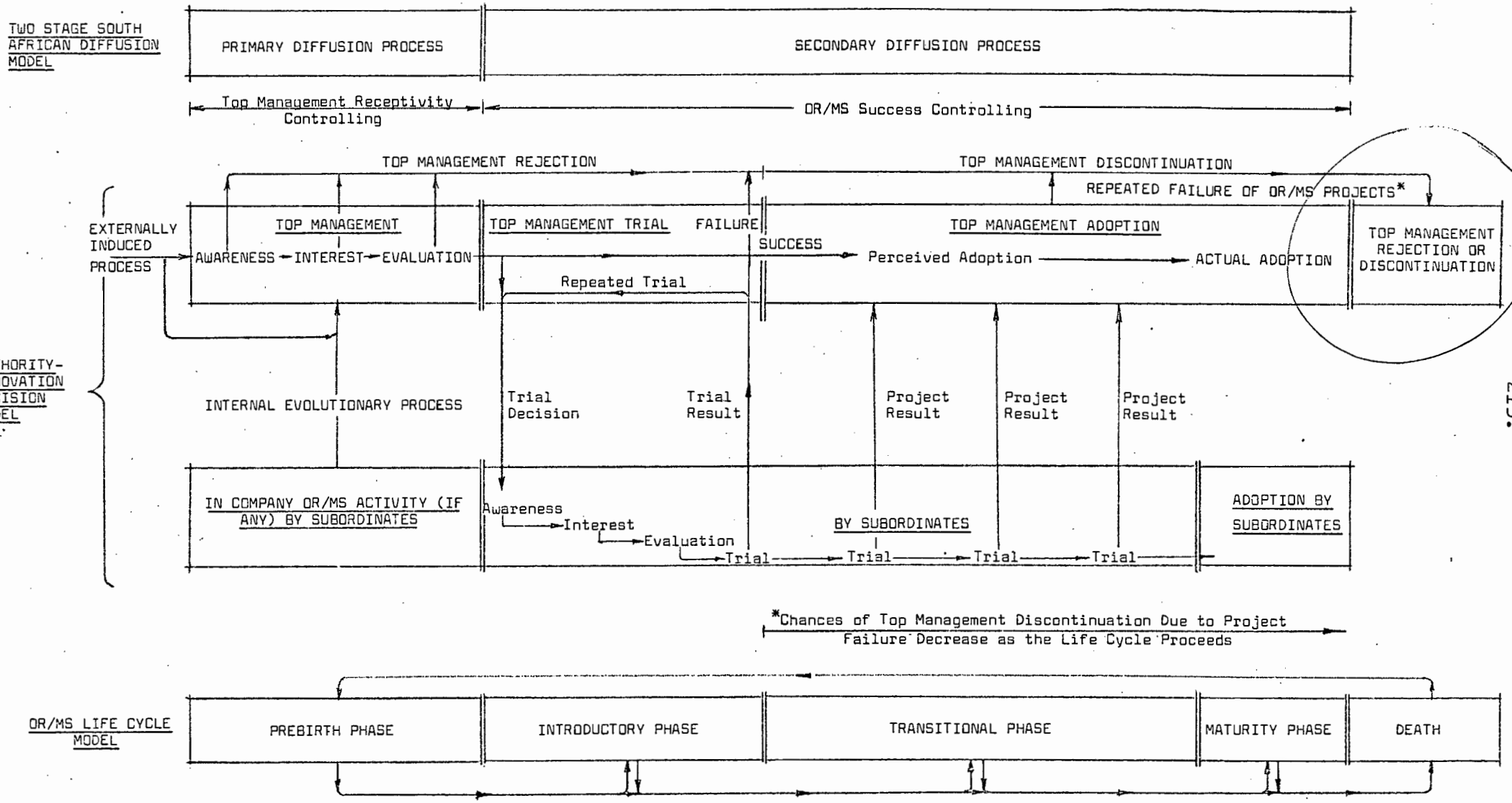
The Secondary Process of OR/MS diffusion is controlled by the factors influencing OR/MS success. These have been examined in earlier chapters and will be discussed again in this chapter. Top Management Support for OR/MS has been found to be one of the

most important factors in the Secondary Process. This is also influenced by the attitudes of Top Management towards OR/MS.

A paradigm showing the interrelationship of the OR/MS Life Cycle, the Authority-Innovation Decision situations, and the Primary and Secondary Processes is shown in Figure 5. Note that although subordinates in an organization can reject OR/MS, complete Rejection (Death) can only occur through a Top Management decision to discontinue OR/MS. Therefore the paradigm shows that the Life Cycle is controlled by the Top Management portion of the Authority-Innovation Decision. Access to the Life Cycle through the subordinate portion of the Authority-Innovation Decision can only be via the Top Management Portion.

In conclusion, it is hypothesised that in less highly industrialized countries like South Africa, OR/MS Authority-Innovation Decision situations tend to become distinct two stage processes. The Primary Process is dependent on those factors influencing the attitudes of Top Management towards OR/MS, and the Secondary Process involves factors which influence the success of OR/MS.

FIGURE 5



MODEL OF THE DIFFUSION OF OR/MS IN SOUTH AFRICAN BUSINESS INCORPORATING

THE AUTHORITY-INNOVATION DECISION MODEL OF ROGERS AND SHOEMAKER AND THE OR/MS LIFE CYCLE MODEL OF RADNOR ET AL

THE PRIMARY PROCESS - RECEPTIVITY OF TOP MANAGEMENT

The Primary Process of an OR/MS Authority-Innovation Decision situation must be considered in terms of the four fundamental stages of Innovation Diffusion. These were discussed in detail in Chapter 1.

Awareness - the individual learns about a new idea but has no information concerning it

Interest - the individual becomes interested and seeks information

Evaluation - the individual decides whether or not to try the innovation

It is clear that the three phases Awareness, Interest, Evaluation are critical to the entire concept of Authority-Innovation Decisions. For example, if Top Management hears about OR/MS but is not sufficiently attracted by it to proceed to the Interest and Evaluation Phases the Primary Process and the OR/MS Life Cycle end abruptly. The three phases are very much dependent upon the attitude of Top Management towards Innovation - the Receptivity of Top Management. This is a composite term used to incorporate the concepts of Awareness, Interest and Evaluation.

Awareness may arise as a result of environmental conditions, an Externally Induced Process. However, if there is an informal OR/MS activity already within the organization, Awareness may arise either as a result of an Internal Evolutionary Process or both.

It is hypothesised that the Primary Process of Authority-Innovation Decision situations is controlled by the Receptivity of Top Management towards innovation, and is therefore influenced by those factors which affect Top Management Receptivity for innovation.

The material presented in previous chapters has indicated that Receptivity of Top Management towards OR/MS is positively associated with the following factors:

- Professionally trained Management with Modern Norms
- Top Management exposure to OR/MS through overseas visits, seminars, journals
- Influence of International parent companies (especially US)
- Influence of Management graduates trained in OR/MS
- Influence of International Management Consultants
- Increasing Competition
- Use of OR/MS by Competition
- Reduced profit, shrinking margins, increased capital costs
- Availability of EDP expertise with OR/MS experience
- Increased size of operation, turnover, product line etc.
- Government Involvement in Economic Planning

The interaction of these factors in a particular organization will result in the development of a Top Management character. One of the traits of this character will be its attitude towards

OR/MS, which has been identified as Receptivity for OR/MS. The influence of each factor in terms of its contribution towards Receptivity is discussed below.

In the context of South Africa several factors are believed to be more important than others. These factors are identified as "Controlling" as they tend to define the overall Receptivity towards OR/MS. The remaining factors are identified as "Assisting". They are not critical in establishing a positive Receptivity for OR/MS but they will improve it.

It is hypothesised that in South Africa there are three Controlling factors:

1. Influence of Internal Parent Companies or Associates (especially US)

   This factor is fundamental in determining the Receptivity of Top Management for OR/MS. Local subsidiaries of International Companies are often set up as mirror images of the parent or associate. As a result OR/MS and DP/MIS groups are already integrated into the organization structure. Statutory reports involving forecasting, budgetting, etc. implicitly demand the use of OR/MS techniques. OR/MS expertise is generally fairly easily accessible from the parent or associate.

2. Professionally Trained Top Managers with Modern Norms

   This type of individual has only started to reach the ranks

of Top Management in South Africa during the last ten years. However the effect upon local business has been significant. Companies have started formal recruiting programmes for management specialists, and departments such as LRP, OR/MS, DP/MIS have been formed.

3. Availability of EDP Expertise with OR/MS Experience

Although Controlling factors 1 or 2 are critical in creating a Receptive attitude towards OR/MS it is essential that effective EDP support is forthcoming. The availability of this support often indicates a commitment to systems development and an established data bank. It may indicate that management is more Receptive to innovation as a result of experiences gained during computerization. Even more important is the fact that the exposure of Top Management to DP personnel with OR/MS experience will generate an awareness of the possible benefits resulting from the implementation of packaged OR/MS techniques such as CPM, LP, and Inventory Management.

In the South African environment Factor 1 very often implies that Factors 2 and 3 will be present. However, there will be local companies without international connections in which only Factors 2 and 3 exist. The presence of at least one of these factors, and preferably all three, is required to create an environment in which OR/MS activities will be favourably received by management. It is hypothesised that OR/MS is unlikely to proceed past the Prebirth Stage of the Life Cycle in the absence

of the three factors. In this environment the Primary Process may end with the rejection of OR/MS by Top Management. The actual level of Receptivity towards OR/MS is dependent upon the relative weight of all three factors in any company. At least one must be present if the OR/MS diffusion process is to proceed to the Introductory Phase of the Life Cycle.

The other factors are believed to increase Top Management Receptivity for OR/MS. These factors are often dependent upon the Controlling factors discussed previously and as a result are described as Assisting and not Controlling.

1. Top Management Exposure to OR/MS Through Overseas Visits, Seminars, Journals

   This exposure is likely to be greater in the case of individuals working in local subsidiaries of international groups, or individuals with modern norms and professional training.

2. Influence of International Management Consultants

   International consultants are more likely to be retained by local companies with International connections, as very few have local representation.

3. Influence of Management Graduates Trained in OR/MS

   In South Africa at this point in time there appear to be two groups of organizations - those that employ management graduates and those that do not. It is impossible to categorise these two groups in terms of differing norms.

However graduates do seem to be attracted to those firms in which previous management graduates have been successful, i.e. those firms with Professional Top Managers with modern norms.

4. Use of OR/MS by Competition

Generally the application of OR/MS is a closely guarded secret in South Africa and details of applications are not readily available. As a result this Assisting factor is not of great significance. While it is true that groups of companies such as the oil companies, mining houses, banks etc. do have formal OR/MS activities this is due more to their international activity than local competition.

5. Increased Competition, and

6. Reduced Profit, Shrinking Margins, Increased Capital Costs

These conditions might force a local organization into OR/MS to control Working Capital or Cash Utilization.

7. Increased Size of Operation, Turnover, Product Line

It has been observed that there is a positive relationship between company size and formal OR/MS. However this relationship only appears to operate above an annual turnover of $400 million. In South Africa this is not a consideration. However it is possible that rapid growth might lead Top Management of local companies to seek

Quantitative tools to improve control. The chances of this happening would probably be related to the presence or absence of the three Controlling factors.

8. Government Involvement in Economic Planning

Although many state controlled institutions in South Africa have formal OR/MS groups and actively employ a number of recognised OR/MS techniques this does not influence the Top Management of local South African business to any great extent. In America, for example, tenders for government projects have to be submitted together with a CPM/PERT Network. This is not the case in South Africa.

In conclusion it is hypothesised that there appear to be three Controlling factors and eight Assisting factors which will positively affect the Receptivity of Top Management towards OR/MS during the Primary Process of Authority-Innovation Decision situations. Receptivity is a composite term which encompasses the three initial phases of all innovation decisions - Awareness, Interest, and Evaluation. The three Controlling factors are of particular importance. They are:

- The influence of International Parent Companies/Associates (especially US)
- The Presence of Professionally Trained Top Managers with Modern Norms
- The Availability of EDP Support with OR/MS expertise

If any one or more of these factors are present in a local business there is a chance that OR/MS will be established on a Trial basis in that company. This corresponds to a movement from the Prebirth to Introductory Phases of the OR/MS Life Cycle. If none of these Controlling factors are present, Top Management of the company will not be Receptive to OR/MS and OR/MS may not reach the Introductory Phase of the Life Cycle. In the context of Authority-Innovation Decision situations this means that Top Management will not take the decision to adopt OR/MS and the Primary Process will not be followed by the Secondary Process.

The Relationship Between Systems Development and Management Receptivity

The Primary Process of OR/MS Authority-Innovation Decision situations is dependent upon the Receptivity of Top Management towards innovation in general and OR/MS in particular.

In addition to OR/MS, it is hypothesised that a relationship exists between Receptivity and Systems Development, and that a company with a low Information Systems Rating (ISR) will have a Top Management team that is fundamentally non-Receptive towards innovation. The hypothesis can be extended to individual divisions of an organization. For example, a company with a low overall ISR and a high ISR for LOCIS sub-system will have Logistics Top Management who are more favourably disposed towards OR/MS than the remaining managers in the company.

depends on where OR/MS will be located.

If this hypothesis is considered in terms of the factors Controlling the Receptivity of Top Management the justification for the relationship can be explained. Local subsidiaries of International Corporations are required to have well developed and effective reporting and control systems. Companies with Professionally trained Top Management will build up their information systems to provide these managers with meaningful and timely information. An effective computer installation will make it easier for these information systems to be developed and implemented. Generally, the overall ISR's of these companies will be high.

In an organization which does not exhibit any of the three Controlling factors the situation is different. Decision making will have to be non-programmed and based upon each manager's interpretation of a situation and his business acumen. Financial controls will be maintained using simple rules of thumb. Typically these companies will have low overall ISR's and will not be Receptive to Innovation such as OR/MS and Systems Development.

This relationship between OR/MS, Systems Development and Receptivity is interesting in the Primary Process, but is critical in the Secondary Process as Systems Development is an important factor influencing OR/MS success.

An Information Systems Rating was developed in Chapter 5 of this thesis. This is used in the field studies to evaluate the level of systems development in each of the ten companies concerned.

OR/MS SUCCESS IN THE SECONDARY PROCESS

The Secondary Process of Authority-Innovation Decision situations for OR/MS has been taken to commence as soon as Top Management orders a trial of OR/MS. This corresponds to the Introductory Phase of the Life Cycle. The success of the Trial takes the OR/MS activity from the Introductory to the Transitional Phase of the Cycle. The Secondary Process is completed when the subordinate levels of the organization genuinely adopt the activity, or when continued failure of OR/MS projects causes Top Management to discontinue their original adoption of the activity. At this point the Life Cycle enters the Death Phase and the Secondary Process is complete.

The first stage in the Secondary Process is the Trial phase. A successful Trial or Trials will lead to adoption by Top Management, failure will cause Top Management rejection. From the outset the Secondary Process is dependent upon the success of the OR/MS activity. The adoption of OR/MS by subordinates is governed by the observed success of OR/MS in successive projects. Although Top Management are perceived to Adopt OR/MS after the Introductory Phase of the Life Cycle, the actual level of Top Management support increases as the OR/MS activity achieves greater success. Therefore in the Secondary Process of OR/MS diffusion it is hypothesised that success is the critical factor in determining whether the Life Cycle enters the Death or Maturity Phases.

A number of factors which are believed to influence OR/MS Success in South Africa are listed below. The list is based mainly upon findings in the US and Europe, but also includes "Systems Development" which appears to be of particular importance locally.

- The Level of Top Management Support
- The Level and Nature of Sponsorship (Participative, Authoritative)
- The Nature and Competence of OR/MS Personnel
- The Relevance and Success of Selected Projects
- The Availability of Computer Support
- The Level of Systems Development within the Organization
- The Formalization of Liaison and Operating Procedures
- The Level of Client Receptivity
- The Influence and Reputation of the OR/MS Group

It is hypothesised that only four of these factors control OR/MS success in South Africa, the remainder assist in the achievement of success. The Controlling factors are as follows:

1. <u>Level of Top Management Support</u>

   The greater Top Management support the greater the chances of success. Top Management support is very much dependent upon Receptivity. Support may take the form of sponsorship where Top Management acts as a client of the OR/MS activity

or alternatively Top Management may force other departments to use the OR/MS group by requesting specific reports and information which cannot be supplied without the assistance of the group. Support is also related to the effort to which Top Management goes to ensure that the OR/MS group has the optimum organization location. The allocation of adequate resources by Top Management goes a long way to ensuring the sustained success of the OR/MS group.

2. Level and Nature of Sponsorship

The greater the degree of sponsorship, the greater the success. Participative sponsorship is more likely to ensure that the OR/MS activity achieves the Maturity Stage of the Life Cycle than is the case with Authoritative sponsorship. The Authoritative approach will achieve success more rapidly, but the OR/MS activity may not be genuinely adopted by subordinates within the organization. Once the sponsor leaves the position he has occupied, the rejection of the activity by subordinates may be sufficient to force Top Management to disband the activity.

3. Level of Systems Development within the Organization

The higher the ISR of the organization the more successful the OR/MS activity is likely to be. OR/MS activities classically encounter problems in data capture and the identification of data sources. These decrease as formal systems development increases.

4. Accessibility of Computer Support

It is not essential for Computer support to be available within the organization, provided that the OR/MS activity does have easy access to an effective Computer installation. This may be through the use of a specialised Bureau or through the use of Time Sharing systems.

It is hypothesised that the four factors are fundamental to the success of OR/MS projects in South African companies. Unless OR/MS activities are supported by Top Management, sponsored, and carried out with adequate EDP support in companies with fairly well developed information systems they are unlikely to be successful. The absence of one or more Controlling factors could result in a discontinuation of OR/MS activity during the Secondary Process due to the failure of OR/MS projects.

The Assisting factors, although important, are not critical to success. They will enhance success but are generally associated with one or more of the Controlling factors. Some factors may be more important than the others.

CONCLUSION

The diffusion of OR/MS in a South African business is an example of an Authority-Innovation Decision situation. It is hypothesised that these decisions on OR/MS consist of two diffusion processes. The Primary Diffusion Process is one in which Top

Management becomes aware of OR/MS and makes a decision to run a Trial to examine the merits of the innovation. It corresponds to the Prebirth Phase of the Life Cycle. In an environment such as America, where Top Management is regularly exposed to innovation this decision forms a relatively minor part of the diffusion process. In South Africa the Primary Process is entirely dependent upon the Receptivity of Top Management for innovation in general and OR/MS in particular.

Receptivity is defined as a composite term involving the first three stages of a diffusion process - Awareness, Interest and Evaluation. Awareness can be Internally or Externally Induced, and as a result subordinates in the organization may already be aware of OR/MS. If management is opposed to innovation, OR/MS will be rejected and the Primary Process will be complete.

It is hypothesised that in South Africa the Receptivity of Top Management during the Primary Process is dependent upon three Controlling factors. At least one of these must be present if the diffusion of OR/MS is to proceed to the Introductory Phase of the Life Cycle.

There are eight Assisting factors which will increase the chances of Top Management being Receptive towards OR/MS.

It is hypothesised that Information Systems Development can also be regarded as an Innovation in South African business. As a result the level of Systems Development will be low in

organizations in which Top Management has a low Receptivity Rating. The implications of this are significant as Systems Development is believed to be one of the factors which control OR/MS success in the Secondary Process. Therefore an OR/MS group which establishes itself in an environment which is non-Receptive towards innovation may find subsequent success difficult to achieve due to the absence of well developed Information Systems.

The Secondary Diffusion Process in Authority-Innovation Decision situations begins when Top Management orders a Trial of OR/MS. This corresponds to the Introductory Phase of the Life Cycle. The success of this Trial may mean that Top Management will decide to formally introduce OR/MS into the company corresponding to the Transitional Phase of the Life Cycle.

There are two possible outcomes of the Secondary Process. Rejection of OR/MS may occur during the Introductory or Transitional Phases of the Life Cycle, due to the failure of the Trial in the Introductory Phase or continued failure in the Transitional Phase. Alternatively the OR/MS activity may be highly successful during the Transitional Phase and this will reinforce Top Management adoption in the Introductory Phase. The Life Cycle then enters the Maturity Phase. In both cases the Secondary Diffusion Process is complete. There is still a chance of Rejection and Death during the Maturity Phase but the probability is low.

The Secondary Diffusion Process is therefore very much dependent upon the successes achieved during the Introductory and

Transitional Phases of the Life Cycle. Research has shown that success is dependent upon a large number of factors and it is hypothesised that in South Africa four factors Control the success or failure of OR/MS projects.

There is a positive relationship between the four factors and success, and the absence of a single factor will increase the chance of OR/MS failure and subsequent rejection. There are a further five Assisting factors which can also influence the chance of Success.

CHAPTER 8

RATIONALE AND METHODOLOGY OF THE FIELD STUDIES

This chapter is devoted to a description of the rationale behind the selection of the ten companies that were examined in the field studies. In addition it is necessary to explain the criteria that were used to identify Top Management, guage Top Management Receptivity to OR/MS, and quantify OR/MS success. Although the concept of an Information Systems Rating was explained in Chapter 5, a summary of the Rating technique is included in this chapter to complete the frame of reference.

pretentious

RATIONALE BEHIND THE SELECTION OF THE COMPANIES INCLUDED IN THE FIELD STUDY

A hypothetical model of the proceeds of OR/MS diffusion was presented in the previous chapter. In order to test the validity of this model it was necessary to carry out a number of in-depth analyses of OR/MS situations in local companies. The main task was to select a suitable cross-section of companies which would provide a meaningful data base with which to evaluate the hypotheses that have been developed.

In South Africa at the moment there is a great deal of secrecy about the work being performed by OR/MS groups, and it is difficult to obtain adequate information about the composition, success, and operations of a group. There are approximately forty formally established OR/MS groups in the country and unfortunately the majority of these are found in companies which display very similar characteristics. As was described in a previous chapter (Chapter 6) these companies tend to be subsidiaries of international corporations. It was believed that the selection of a sample from these companies alone would present a very biased picture of the South African business environment.

Five criteria were initially established to assist the selection process. It was hoped that a sample based upon these criteria would be large enough to permit meaningful conclusions to be drawn from the data. The criteria were as follows:

1. Each organization had to house at least one activity which could be classified as OR/MS, based upon the definition of OR/MS stated in Chapter 2. "Activities which were performing work utilising the newer methods of mathematical analysis and/or were involved in non-routine computer system activities." The activities did not have to be formally identified as OR/MS.

2. The companies were to be chosen across a spectrum of different industries and a wide range of annual turnover, commencing with a concern similar to those used in the Northwestern sample of US companies, and ending with a company with an annual turnover of a little more than R10 million. This is approximately the lowest turnover encountered in the "Top 100 South African companies" listed.

3. The sample had to contain examples of successful and unsuccessful OR/MS activities in order to test the hypothesis of the factors influencing OR/MS success.

4. The companies selected had to be willing to permit unrestricted access to the OR/MS activity, Top Management, subordinates in all divisions and data banks; as well as the subsequent publication of the findings of the study (in a disguised form if necessary).

5. The activity had to be established for at least two years to enable meaningful observations to be made about its position

in the Life Cycle and to test Top Management's knowledge of its activities.

As it happened criterion (4) turned out to influence the selection of OR/MS groups to a greater extent than the other four criteria. Many organizations with established OR/MS groups would not allow any information to be published about them even in a disguised form. Firms that had experimented with OR/MS with limited success were generally not disposed to discuss or reveal their misfortunes.

The five criteria made the identification and selection of groups fairly difficult. During the study eighteen suitable groups were identified and approached. Permission to carry out in-depth study was granted in thirteen cases and the groups concerned were examined and documented. The management of three of the thirteen companies subsequently decided not to allow the results of the studies to be published and they have had to be withdrawn.

In the ten companies remaining only two groups could be regarded as formally recognised OR/MS activities. A third group existed in a Production Planning function which was itself formally recognised by management. A fourth group was located in a Merchandising division and provided the Merchandising Director with a great deal of relevant information. Top Management were hardly aware of the existence of this group. Other groups were located in EDP, Finance, etc.

Unfortunately it was not possible to obtain case studies in as wide a cross-section of companies as had originally been planned. Although the largest company in the sample had a 1973 turnover of R310 million, the majority had turnovers between R10 and R20 million annually. However in the sample of ten companies it was possible to achieve a reasonable blend of successful and unsuccessful OR/MS activity. Six of the OR/MS groups appeared to achieve a reasonable level of success whilst four were virtually non-productive.

see p. 369

The average duration of each field study was approximately two and one half months. During this period the writer was able to observe the progress of individual OR/MS projects in detail and was able to spend some time working with the OR/MS activity in each company. Many of the studies extended over two years in time so that it was possible to watch the changing attitudes and atmospheres within the company.

?

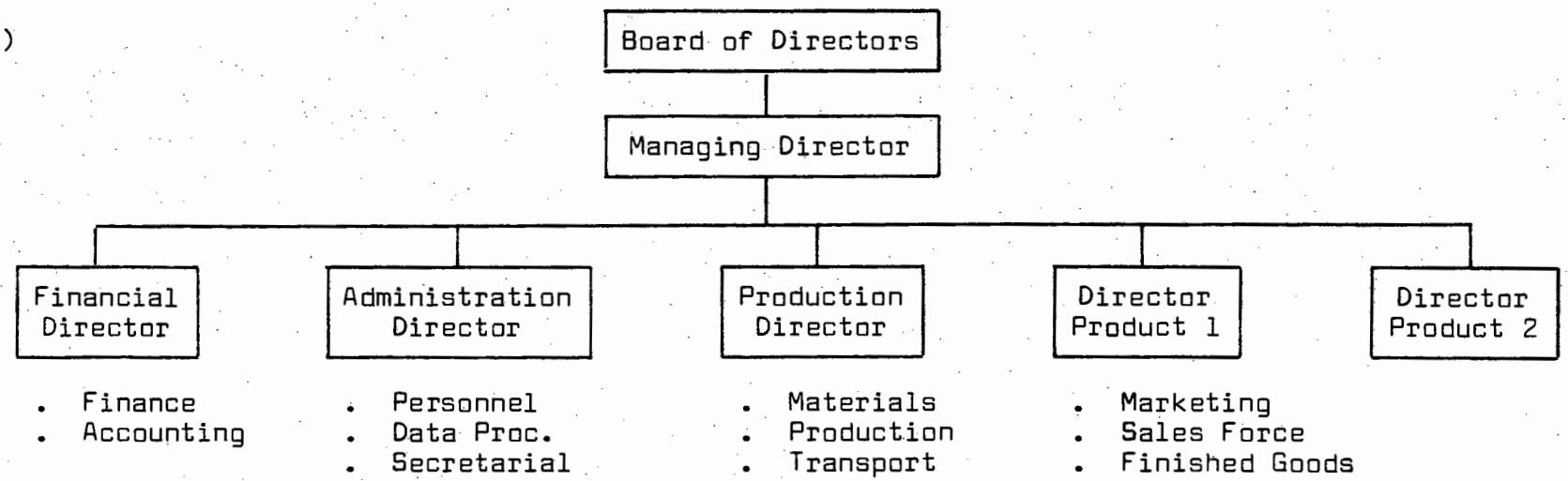
If the average is 2½ months & "many" (out of 10) were over 2 yrs — some must have been days.

By the time the tenth field study had been completed twenty-five OR/MS projects had been evaluated and assessed. Extended discussions on OR/MS in South African business had been held with over sixty senior executives, and in several instances discussion still continues. The data obtained in the field studies was so extensive that it has been necessary to confine the description of findings only to those areas which concern the model of OR/MS diffusion.

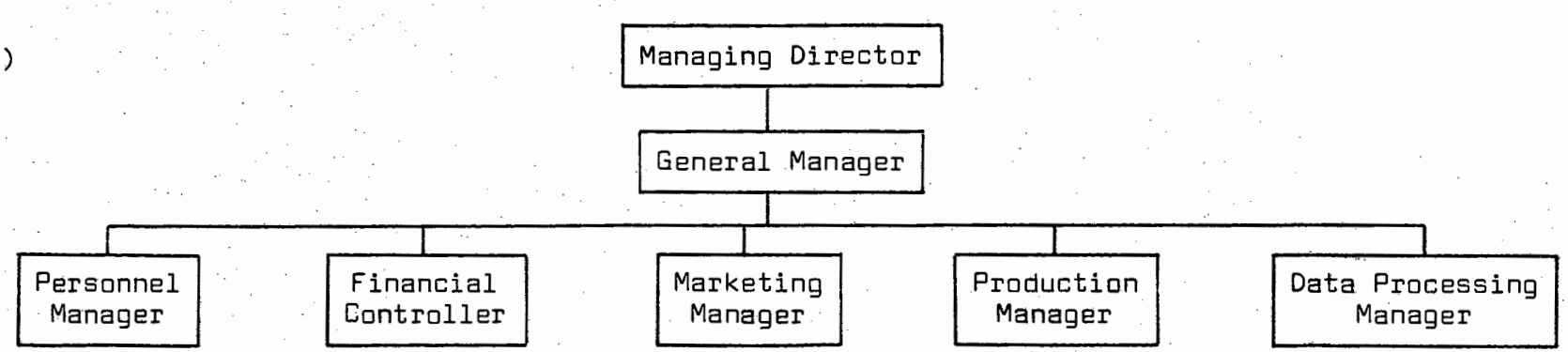
FIGURE 6

TOP MANAGEMENT POSITIONS IN TWO TYPICAL SOUTH AFRICAN ORGANIZATION STRUCTURES

(A)



(B)



CLASSIFICATION OF TOP MANAGEMENT

Prior to the evaluation of the results obtained during the field studies it is necessary to define which levels of management are included in the term "Top Management". There is a considerable difference in the nomenclature relating to the levels of Senior Management in South African companies and their American counterparts. Figure 6 depicts Top Management levels in two typical South African organization structures.

During the field studies it was found that the organization structures encountered were usually a blend of the two shown in Figure 6. The incidence of either structure does not appear to depend on size, industry or other related criteria. A company with a significant marketing orientation may rate a Managing Director, Marketing Director coupled with a Financial Controller and Production Manager.

The term "Top Management" has been taken to include the group of individuals who report directly to the Managing Director, or alternatively through the General Manager to the Managing Director. Other individuals are only included in situations where they exert a particular degree of influence.

Makes it a non-operational definition

The analysis of the field studies reported in the following chapter refers to criteria such as Top Management "Receptivity". In all instances the attitudes and opinions of the members of the Top Management team were obtained by personal interview with the individuals concerned. In each field study

the members of the company who were taken to represent Top Management are listed in the description of the company.

TOP MANAGEMENT RECEPTIVITY TO OR/MS

It has been hypothesised that the controlling factor in the Primary Diffusion Process is the Receptivity of Top Management to OR/MS. Receptivity has been used to describe the thought process that occurs prior to Top Management's decision to embark on a preliminary Trial of OR/MS. It involves the Awareness, Interest and Evaluation stages of the Diffusion process.

The field studies describe situations in which OR/MS activities were already established, although their positions in the Life Cycle varied from the Prebirth Phase to Maturity. The Receptivity evaluation was on the basis of Top Management's observed awareness of and interest in an established activity in particular and change in general. It was felt that an executive who displayed a low Receptivity rating towards OR/MS in these circumstances would be most unlikely to sponsor or support the activity at any stage of the Life Cycle.

The assessment of Receptivity was based upon extended discussions with all members of Top Management over the period of the field study. Discussions were designed to evaluate the individual's knowledge of what the OR/MS activity in the organization was actually trying to do, to what extent the individual supported the activity, and his attitude towards various forms

of innovation - computers, management graduates, etc.

Was this formalized into a questionnaire?

As a result of the interviews it was found that members of Top Management of companies in South Africa could be classified in terms of one of four categories based upon their Receptivity towards OR/MS.

Why not call it a 4-point scale?

E: Enthusiastic Supporter

These individuals do not correspond precisely to the classification of "Innovator" which was one of the five adopter categories proposed by Rogers and Shoemaker. They are however extremely interested in Innovation and Receptive towards it. They are aware of the aims and objectives of the OR/MS activity in their organizations and are willing to give their unqualified support to the activity. They believe that the introduction of OR/MS activity can result in significant improvements in the operation of the organization.

S: Supporter

These individuals are more critical of the implications of the attitude "OR/MS will solve all our problems". They tend to believe that there are certain areas in which OR/MS has application and will defend the implementation of OR/MS recommendations in those areas. They are generally in favour of the planned and controlled introduction of innovation into their business, provided they can see potential benefits resulting from the Innovation.

I: Indifferent Observer

The most marked characteristic of this group of Top Managers is that they do not wish to get involved in innovative activity. This means that they will neither support the innovation nor are they actively hostile. They are generally unaware of OR/MS activities in the organization, alternatively they are cynical about possible benefits resulting from the implementation of OR/MS recommendations.

H: Hostile

These individuals are opposed to innovation and actively attempt to destroy innovative activity, such as OR/MS, by being non-supportive and by allowing their subordinates to ignore OR/MS recommendations. The majority of Top Managers classified as hostile were fully aware of the nature of OR/MS projects being carried out in their organizations, and went out of their way to ensure that they failed.

As the field studies will show members of the Top Management team in an organization will tend to have similar Receptivity Ratings. This may be because promotion of senior managers to Top Management positions will often be dependent upon the individual exhibiting the same norms as the existing members of Top Management.

It is hypothesised that the Primary Process of OR/MS Diffusion is dependent upon the Receptivity of Top Management. In other words, OR/MS activities are more likely to proceed along the Life Cycle from the Prebirth Stage to the Introductory Phase

if Top Management has a Supportive or Enthusiastic rating.

CONTROLLING AND ASSISTING FACTORS

INFLUENCING RECEPTIVITY

The model of the Primary Diffusion Process hypothesised that the Receptivity of Top Management towards OR/MS was dependent upon a number of Controlling and Assisting environmental and internal factors. This hypothesis is tested in the field studies and it was necessary to develop some method of representing the degree to which each of the factors was present or absent in each of the ten studies. The main problem here is the difficulty involved in quantifying many of the factors concerned.

In order to arrive at some form of rating, a simple classification was made which depended upon the researcher's personal observation. An attempt was made to ensure that the ratings were based upon some observable characteristics to minimize the chances of bias. The three ratings were as follows:

P: Pronounced

In this case the factor is definitely observable in the organization to a significant degree. The majority of characteristics which have been found to be associated with this factor are present.

N: Negligible

Few if any, of the characteristics which are associated with this factor can be observed in the organization.

M: Moderate

The factor is believed to exert some influence in view of the fact that a limited number of the characteristics associated with the factor can be observed in the organization.

On the basis of this three grade rating it is possible to express the degree to which each of the Controlling and Assisting factors influence Receptivity in a company. The characteristics associated with each factor are listed below.

Repeat of p 218ff.

(a) CONTROLLING

1. Influence of International Parent Company/Associate

Significant Characteristics:

- Subsidiary or Associate of International Organization
- Reporting Systems based on International Specifications
- Budgets set/controlled by International Board
- OR/MS used by Parent/Associate Company
- Expatriates seconded to local Top Management Team

2. Professionally Trained Top Management with Modern Norms

Significant Characteristics:

- Majority of Top Management have degrees or professional qualifications
- Company not family controoled
- Promotion from outside company acceptable
- Company quoted on Johannesburg Stock Exchange

- Board of Directors are regarded as competent and progressive by investors

3. Availability of EDP Support with OR/MS Expertise

Significant Characteristics:

- DP Department has systems analysts, programmers, etc. with OR/MS experience
- DP Manager has experience of OR/MS
- Manufacturer (or bureau) supplying computer actively supports OR/MS
- Specialised OR/MS packages commercially available
- Company uses Time Sharing Facility which supports OR/MS

(b) ASSISTING

1. Top Management Exposure to Innovation through Overseas Visits, Seminars, Education

Significant Characteristics:

- An established programme for overseas visits exists
- Company runs regular in-company training programmes
- Company sends managers on external training programmes
- Company sponsors further education
- Company actively encourages personnel to undergo further education

2. Influence of Management Graduates Trained in OR/MS

Significant Characteristics:

- Company sponsors potential MBA, B.Bus.Sc., B.Sc. Comp.S., candidates

- Company runs formal recruiting at universities
- Company has a reputation for employing "bright young men"
- Company employs MBA, B.Bus.Sc., Comp.Sc. graduates
- Company encourages promotion of young managers

3. Influence of International Consultants

Significant Characteristics:

- Company uses local consultants
- Company uses overseas consultants
- Consultants have been employed on OR/MS activities
- Company feels that consultants are at times necessary
- Consultant's recommendations are implemented

4. Use of OR/MS by Competitors

Significant Characteristics:

- Extent to which competitors employ OR/MS

5. & 6. Increased Competition, Shrinking Margins, Reduced Profits, Increased Capital Costs

Significant Characteristics:

- Market share is decreasing
- Profits are dropping
- Margins are being cut
- Competition is increasing
- Financing is more difficult

7. Increased Size of Operation, Turnover, Product Line, etc.

Significant Characteristics:

- Turnover has increased regularly during the last five years
- Product line is increasing
- Sales force is expanding
- Inventories and work in process are growing
- Company has committed itself to significant future expansion

8. Government Involvement in Economic Planning

Significant Characteristics:

- Degree to which company is involved in projects dealing with Government Departments which necessitate the application of OR/MS

On the basis of the characteristics it is possible to assign a rating to represent the influence of each of the eleven facilitating factors. The ratings for each factor will then be used to generate an Overall Rating for Controlling Facilitating factors and for Assisting Facilitating factors. It is hypothesised that there is a definite relationship between the observed Receptivity of Top Management in an organization and the ratings achieved for Controlling factors. This hypothesis is tested in the following chapter.

FACTORS INFLUENCING OR/MS SUCCESS IN THE SECONDARY PROCESS

Once an OR/MS activity has been introduced into a company during the Primary Diffusion Process its further existence is dependent upon its success. Research has shown that success is dependent upon a number of factors and it is hypothesised that several should play an important role in the South African environment. In order to establish whether there is a relationship between success and these factors, it is necessary once more to present some quantifiable approach which can be used in any company.

The following characteristics are used to assess the degree of influence of the Controlling and Assisting factors which are believed to be associated with Success. The classifications of Pronounced, Moderate and Negligible are used once again to express the degree to which each factor is observed.

(a) CONTROLLING

1. Level of Top Management Support

Significant Characteristics:

- Management has allocated funds and personnel to support the project
- Management influences departments to use OR/MS
- Management has appointed a sponsor for OR/MS
- Management formally reviews progress of OR/MS projects
- Management has introduced OR/MS into the Reporting system of the organization

2. Level and Nature of Sponsorship

Significant Characteristics:

- Sponsor is a member of Top Management and/or Sponsor is a department in the organization
- Sponsor has a knowledge of OR/MS
- Sponsor has tried to "sell" OR/MS rather than enforce it (Authoritative versus Participative approach)
- Sponsor has credibility within organization
- Sponsor allows other departments to use OR/MS

3. Level of Systems Development within Organization

Significant Characteristics:

- Overall Information Systems Rating of the Organization

4. Availability of Computer Support

Significant Characteristics:

- Pronounced
  - if in-house DP department has OR/MS expertise, suitable OR/MS software, and is co-operative

  or
  - if OR/MS activity has access to time-sharing system supporting OR/MS
- Moderate
  - if OR/MS activity has access to bureaux which specialise in OR/MS

  or
  - if in-house DP department has no particular OR/MS experience but has competent systems analysts, programmers etc.

(b) ASSISTING

1. Influence and Reputation of OR/MS Group

Rating based upon analyst's personal evaluation of perceived status of group amongst clients, sponsors, non-OR staff groups and External publics

- Pronounced
  - uniformly high perceived status, general satisfaction, no major criticisms
- Moderate
  - some groups dissatisfied, some satisfied clients and sponsors

2. Relevance and Success of Selected Projects

Rating based upon analyst's personal evaluation of Projects tackled by group

- Pronounced
  - projects relevant and successful to partially successful
- Moderate
  - projects of no great relevance but successful to partially successful

3. The Formalisation of Liaison and Operating Procedures

Significant Characteristics:

- Formal OR/MS co-ordinating programme
- Formal project selection team with management
- Formal presentation of project proposal
- Formal progress review meetings
- Formal reporting and documentation requirements

4. The Level of Client Receptivity

Rating based upon analyst's personal evaluation of attitudes amongst user departments

- Pronounced
  - users allow OR/MS group to select projects, or users and OR/MS group negotiate projects
- Moderate
  - users select projects for group to work on

5. Nature and Competence of OR/MS Personnel

Significant Characteristics:

- Group leader has organizational and EDP experience
- Group leader has high status amongst clients
- At least one experienced EDP personnel in group
- Group does not consist entirely of OR/MS analysts
- Members temporarily seconded from organization to OR/MS group

It will be seen that many of the Assisting factors are evaluated on the basis of the analyst's assessment of conditions within the organization. Although this approach tends to be subjective, the ratings were usually performed after the writer had spent six to eight weeks in each organization. Furthermore, any bias would be common to all ten studies and should therefore not influence the results unduly.

See p. 236

Not true

DETERMINATION OF OR/MS SUCCESS

The factors listed in the previous section are believed to be associated with OR/MS success. In order to test the

hypothesis relating Success to these factors it is necessary to establish some manner of measuring Success. In Chapter 4 the problems involved in quantifying Success or Effectiveness were discussed at length. A measure of Success was defined as:

$$\left(\frac{\text{Number of Jobs Completed and Used}}{\text{Number of Jobs Started}}\right)$$

In context of this thesis this percentage is not meaningful as several of the OR/MS activities investigated were still engaged on their first and only project. It is, in fact, difficult to use this measure of success until the activity has achieved the Transitional or Maturity Stages of the Life Cycle. It certainly does not apply to groups in the Prebirth and Introductory Phases.

There are several possible ways of measuring success:

1. Percentage of jobs used
2. Success levels as perceived by the OR/MS manager
3. Top Management support perceived by the OR/MS manager
4. Client Receptivity
5. Degree of Project Backlog
6. Percentage of Projects generated by Non-OR/MS personnel

It is difficult to use any of these in a study in which activities are at different stages of the Life Cycle, which is true in the case of the ten field studies described here. For example the situation of one group in the Introductory Stage and

another in the Maturity Stage are very different. Measures 1, 4, 5 and 6 cannot be applied to a group that has not yet moved from the Introductory Phase.

Several of the case studies involved groups which were not intended to do anything more than provide service for one specific project in the immediate future. In this situation measures 5 and 6 would be meaningless.

Finally it was decided to use Top Management's assessment of the results of projects as the measure of Success. This technique is not mentioned by the Northwestern Research Group, but it does appear to be a logical way of measuring success. OR/MS activity in an organization depends upon Top Management support for its continued existence, as it is only Top Management that can finally make the decision to discontinue OR/MS. As a result the observed success of OR/MS as perceived by Top Management is the fundamental criterion on which the Life Cycle of an OR/MS activity depends.

The approach that was adopted in the field studies was to ask each member of Top Management to rate the success of OR/MS projects on the following scale:

S+	Success plus	Results (i.e. savings) of the project have more than justified time and money put into it. The project has been an outstanding success

S	Success	The company has benefitted financially by the project and overall efficiency has improved
M	Moderate Success	The project has achieved certain improvements but it is not possible to quantify the financial savings involved
N	No change	The project has not adversely affected the running of the company. No savings and no marked improvements are detectable
U	Uncertain	I do not know enough about the project to comment
F	Failure	In my opinion the project has not been a success, costs have exceeded savings, efficient has not increased

The table shows that different ratings were assigned to the "Uncertain" and "Failure" responses. It was apparent that managers were prepared to identify a project as a failure even though it was incomplete or fairly new. As a result the "Uncertain" response was taken to mean: "Although the project is new (Although I do not know very much about the project) it does not appear to be unsuccessful."

Managers were asked to explain what criteria they used

to evaluate the Level of Success. It was found that managers often revised their expressed perceptions of success as they proceeded with the explanation. Generally Success was evaluated in terms of criteria such as Stated Objectives, Financial Savings, Increased Efficiency, etc.

Several of the OR/MS groups had completed two or more projects. The Success ratings for each project were recorded separately and were not averaged out to give an Overall Success Rating. The reasons for the different levels of Success achieved by a single OR/MS activity on different projects often provide a useful insight into the relationship between OR/MS Success and the Controlling and Assisting factors.

INFORMATION SYSTEMS RATING

The concept of an Information Systems Rating (ISR) was described in detail in Chapter 5. In order to complete this statement of criteria used in the field studies, the method of calculating ISR's is briefly reviewed here.

Any organization will possess formally or informally developed Information Systems. An ISR measures the extent to which the various modules of the Overall Information System are formally developed. There are four functional Information Systems which can be recognised in most organizations. These are:

PAOCIS - Physical Asset Operational Control Information System

LOCIS - Logistics Operational Control Information System

FOCIS - Financial Operational Control Information System

MOCIS - Manpower Operational Control Information System

Each of these have a number of sub-systems which are made up of modules. For example, the LOCIS system has RMOCIS (Raw Material Control), PROCIS (Production Control), and SPOCIS (Saleable Product Control) sub-systems. Each of these has a number of modules. RMOCIS for example has four modules:

- Materials Scheduling
- Purchasing
- Receiving, Inspecting, Warehousing
- Stock Control - Raw Materials

It is possible to assess the level of systems development in the RMOCIS sub-system by checking which of the 4 modules are formally designed, implemented, and operating.

On the basis of an evaluation of the extent to which the individual modules are formally supported in an organization it is possible to arrive at an ISR for each of the four main systems.

PAOCIS has 8 possible modules

LOCIS has 14 possible modules

FOCIS has 15 possible modules

MOCIS has 7 possible modules

An organization which exhibits four clearly defined PAOCIS modules will therefore receive a 0,50 PAOCIS rating.

The overall ISR is based upon the weighted contribution of each of the four system ISR's. It is, in fact, the total number of modules supported divided by the maximum possible number of modules which can be supported. It is hypothesised that there is a relationship between the overall ISR and the Receptivity of Top Management in that organization.

CONCLUSION

This chapter has been used to define the terms and rating systems used in the field studies. The criteria used to select the ten companies described in the next chapter have been reviewed. The levels of management included in the term "Top Management" have been defined as those executives who report directly to the Managing Director, or through the General Manager to the Managing Director.

Rating scales to determine Receptivity and OR/MS Success have been proposed, as well as scales for the quantification of the Controlling and Assisting Factors facilitating the Primary and Secondary Diffusion Processes.

CHAPTER 9

TEN FIELD STUDIES OF MANAGEMENT SCIENCE SITUATIONS IN SOUTH AFRICA

A model of the process of OR/MS diffusion in South African business was presented in an earlier chapter of this thesis. The model was based upon a number of hypotheses which were derived from the results of the International Programmes on the Diffusion of OR/MS. In order to test the validity of the model a series of in-depth field studies were performed in ten South African companies. The companies varied significantly in size, profitability, area of operation, etc. The only similar feature in all ten companies was the presence of an OR/MS activity. The activities ranged from a formally constituted Management Science Group with a complement of five OR/MS analysts to a single statistician located in the Merchandising Division of a large company.

This chapter describes each of the OR/MS situations in some detail. Although companies and individuals are disguised, the field studies give brief outlines of the performance and history of each company, details of the individuals making up the Top Management Team, and finally an overview of the activities and performance of the OR/MS groups. The results of the various analyses carried out in each company are briefly presented. The following chapter is devoted to a closer examination of the results of the field studies in terms of the model of OR/MS diffusion in South Africa.

In order to describe how the data in the field studies was collected, a detailed account of the field study carried out in Company Alpha is given in Appendix B which is located at the end of the thesis. This company was chosen as it is an excellent example of a formal OR/MS activity in a typically South African business which has reached the Maturity phase of the Life Cycle.

"it is the "best"?

A. RESULTS OF THE FIELD STUDY IN COMPANY ALPHA

Company Background

Company Alpha manufactures and imports engineering and mining equipment. It has long established connections with the mining industry in the Republic and is the South African agent for many international companies. Company Alpha has been in operation in South Africa for nearly forty years and has maintained a satisfactory profit and sales record during this time. The company is quoted on the Johannesburg Stock Exchange and the profit performance between 1969 and 1973 is given in Table 19.

TABLE 19

PROFIT PERFORMANCE FOR COMPANY ALPHA*

Year ending Feb. 28th	1969	1970	1971	1972	1973
Profit before Tax (R000)	2 700	2 360	1 800	1 960	2 900

*Source: Company Records

The company does not disclose turnover but estimated 1973 turnover was R32 million. The drop in profits during the period 1971/1972 came from the liquidation of a company which had been unprofitable for some years.

Company Alpha employs about 1 200 people. The company has five operating divisions, three of which manufacture and distribute equipment whilst the other two are involved in the design and construction of engineering plant. The Head Office

is in Johannesburg and there are two service branches in the OFS and Northern Cape. The company does not have overseas shareholders and cannot draw on OR/MS expertise from parent companies. However many of the international companies represented by Alpha in South Africa have considerable OR/MS competence. Frequent trips to South Africa by overseas principals and return visits by local Top Management have been responsible for many of the OR/MS techniques introduced into the company.

History of OR/MS Activity

There is a permanent OR/MS group located at Head Office which functions as a staff department for the whole company. The OR/MS group is identified as a Management Service Group and is headed by an engineering graduate with a management degree. There are four other group members.

The first OR/MS activity started in 1966 when the present General Manager introduced a CPM/PERT activity which was used by the Construction Division. In 1968 consultants were called in to assist with the introduction of a computer system to process accounting work. Shortly after this the consultants designed and installed a computerised inventory control system (1969-1970).

The present Management Services Manager joined the company in 1968 to assist the consultants with the computerisation exercise. He recruited an EDP Manager from IBM and together with the consultants completed the computerisation of the accounting and financial control system. Two additional analysts were recruited

in 1970 to assist with the Inventory System.

The consultants left at the end of 1970 and in December 1971 a formal Management Services Department was created. The two analysts working on the Inventory project were seconded to the MS Department together with the two engineers who had been responsible for the CPM/PERT projects.

Between 1971 and 1973 the MS Department refined the Stock control system and continued to supervise CPM/PERT projects. New projects in Financial Forecasting and Long Range Planning were started in 1972. The MS group leased an intelligent terminal from a Time-sharing company in 1972 to build a Financial Model of the company. This was a temporary measure as Alpha had ordered a large computer which was scheduled for delivery in early 1974. This machine would provide on-line terminal facilities which would be used for Accounting, Stock Control and OR/MS operations.

Top Management Profile

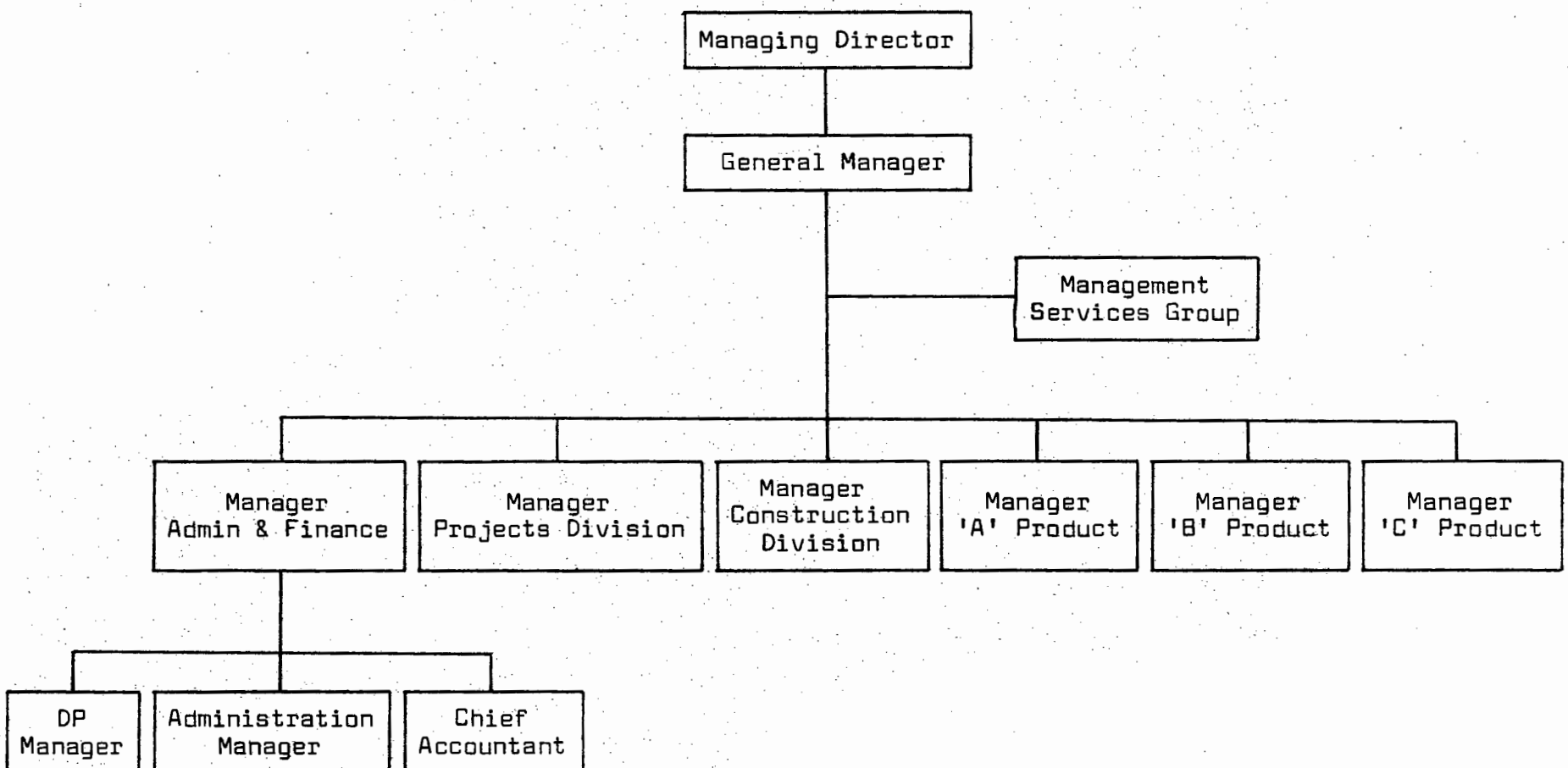
Ten members of Alpha were taken to represent the Top Management of the company. The organization structure of the company is shown in Figure 7. It will be seen that three lower levels of management are included in the diagram. Two of these, the Administration Manager, and the Chief Accountant were included in the Top Management classification. This decision was taken because of the very unfavourable attitudes towards OR/MS displayed by the Financial Manager and the Administration Manager. This attitude was offset by the positive attitudes displayed by

See p 238

but did they have any influence

F I G U R E 7

PARTIAL ORGANIZATION STRUCTURE OF COMPANY ALPHA*



* Source: Company Records as at 30.11.1973

↑ Not clear

the DP Manager and the Chief Accountant. Because of this conflict it was necessary to reflect the views of all three accounting/administration executives. Table 20 gives summary details of Top Management personnel of Alpha. Also included in the table is information relating to the Management Services Manager and the DP Manager.

TABLE 20

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT AT COMPANY ALPHA (30.11.1973)

Managing Director (65) Founder and majority shareholder. B.Sc. (Mech.) Particular competence in Engineering R & D. Responsible for early success of Alpha with overseas franchise.

General Manager (37) B.Sc. (Mech.) Joined Alpha directly from University in 1960. General Manager since 1967. Travels extensively. Responsible for the introduction of OR/MS, the formation of the Management Services Group and the computer installation. OR/MS sponsor.

Manager - Admin. and Finance (48) CA(SA), CWA. Partner in a firm of auditors. Joined in 1955 as Chief Accountant and was promoted to his present position in 1967.

Chief Accountant (41) CA. Joined Alpha in 1962 from Britain. Ten years experience with a large construction firm.

Administration Manager (58) CIS. Joined Alpha in 1946 after World War II.

Divisional Managers (35-55) All five have been with Alpha for over ten years. All have degrees in Civil or Mechanical Engineering, except the manager of the Construction Division (55).

↑ who has what?

Management Services Manager (36) B.Sc. (Mech.), MBA. Joined Alpha in 1968 after several years in America. Started the MS group and recruited personnel.

Data Processing Manager (38) Joined Alpha in 1967 from IBM. Fifteen years DP experience.

ANALYSIS OF COMPANY ALPHA

OR/MS Life Cycle

The OR/MS Group is formally integrated into the organization structure of Company Alpha. OR/MS activity started as a result of an Externally Induced process in 1966 when the General Manager sent an engineer in the Projects Division to study CPM/PERT in America. OR/MS passed from the Introductory Phase of the Life Cycle to the Transitional Phase in 1967 with the success of the first two CPM/PERT projects. From this point on all projects in excess of R50 000 had to be PERT controlled. The Maturity Phase of the Life Cycle was reached in 1971 when the MS Group was formed. By this time OR/MS had been adopted at virtually all levels of Alpha.

Primary and Secondary Processes

The Primary Diffusion Process in Alpha was completed when Top Management decided to test CPM/PERT in 1967. The Secondary Process was completed at some time between 1971 and 1973. Both Inventory Management and CPM/PERT had become routine parts of the management process of Alpha, and the MS Group was a permanent part of the organization structure.

Sponsorship

The present General Manager has sponsored the OR/MS group from the outset. Initially as Manager of Projects Division he realised that CPM/PERT would be an extremely important tool and arranged for its introduction. His competence and status was

adequate for him to persuade most of senior management in Alpha that CPM/PERT had possibilities. All subsequent projects, Data Processing, Inventory Control, Financial Forecasting and Long Range Planning have been introduced and supported by him. The status of the General Manager has been significantly enhanced by the success of the OR/MS projects.

PRIMARY PROCESS AT COMPANY ALPHA

Receptivity of Top Management

The attitude of Top Management towards OR/MS is clearly shown in the following table which is based upon the Receptivity quiz described in the previous chapter.

T A B L E 21

RECEPTIVITY OF TOP MANAGEMENT OF COMPANY ALPHA TOWARDS OR/MS

Top Manager	Receptivity
Managing Director	E
General Manager	E (sponsor)
Financial Manager	I
Chief Accountant	S
Admin. Manager	H
Manager Projects	S
Manager Construction	H
Manager Division A	S
Manager Division B	I
Manager Division C	S

(Key: E = Enthusiastic; S = Supportive; I = Indifferent; H = Hostile)

The results show a significant difference in the levels of Receptivity of the various members of the management team. The enthusiasm of the Managing Director and General Manager is partially offset by the indifference of the Financial Manager and the hostility of the Administrative Manager. The Receptivity of the Divisional Managers shows that they would probably be generally in favour of OR/MS.

The table of ratings shows that the Top Management of Alpha as a whole could be expected to support OR/MS, however the attitude of some of the Top Management team could adversely affect OR/MS implementation. The very high rating of the General Manager who has acted as the sponsor since the creation of the Group has probably been responsible for the success of OR/MS in Company Alpha.

already determined?

Table 22 gives the rating of factors believed to facilitate Receptivity in South African business and shows that Company Alpha could be expected to be a favourable environment for the Primary Diffusion of OR/MS.

The development of Information Systems in Company Alpha is defined in Table 23 which gives the ISR's for the various systems. It is interesting to observe that the systems which receive the lowest ISR ratings in Company Alpha are those associated with the members of Top Management with the lowest Receptivity. The Financial Manager (Indifferent) and the Administration Manager (Hostile) are responsible for the Financial Control System (0,65)

and the Physical Assets system (0,37). The overall ISR of 0,68 depicts a company with a reasonably high level of systems development.

T A B L E 22

FACTORS AFFECTING RECEPTIVITY AT COMPANY ALPHA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	M
- Professional Trained Top Management	P
- Availability of EDP Expertise	P
ASSISTING	
- Top Management exposure to innovation	M
- Influence of Management Graduates	P
- Influence of International Consultants	M
- Use of OR/MS by Competition	N
- Increased Competition, Reduced profits	M
- Increased size of operation	M
- Government involvement	N

(Key: P = Prounced; M = Moderate; N = Negligible)

T A B L E 23

INFORMATION SYSTEMS RATING IN COMPANY ALPHA

LOCIS	system ISR	= 0,85
PAOCIS	system ISR	= 0,37
FOCIS	system ISR	= 0,65
MOCIS	system ISR	= 0,71
OVERALL ISR		= 0,68

SECONDARY PROCESS AT COMPANY ALPHA

Theoretically OR/MS is successfully established as a permanent part of the organization structure of Company Alpha. The activity has reached the Maturity Stage of the Life Cycle and two applications are working effectively. However, research has shown that even in the Maturity Phase there is still a chance of rejection as a result of OR/MS failure. Although the impact of OR/MS failure is not as marked at Maturity as it is during the Introductory Phase, it can force Top Management to discontinue the adoption of OR/MS. The Secondary process of OR/MS diffusion is dependent upon Success and Table 24 below displays the impressions of Top Management on the outcome of the four OR/MS projects.

T A B L E 24

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT ALPHA

Manager	Inventory	CPM/PERT	Fin Forecast	LRP
MD	S+	S+	S	U
Gen Man	S+	S+	S+	U
Fin Man	M	M	M	U
Chief Acc	S+	S	S+	U
Admin Man	S	S	U	U
Man Proj	M	S+	S	U
Man Cons	M	S+	U	U
Man Div A	S	S	U	U
Man Div B	S	S+	S	U
Man Div C	S	S+	U	U

Key: S+ = Success Plus; S = Success; M = Moderate Success;
N = No Change; U = Uncertain; F = Failure

On the basis of these results Top Management appear to regard the Inventory Exercise as a Success, the CPM/PERT project an Outstanding Success and the Financial Forecasting project a Moderate Success. The Long Range Planning project is still an unknown quantity. As far as Top Management attitudes are concerned these range from the enthusiasm of the General Manager to the cynical attitude of the Financial Manager.

The Success of OR/MS is believed to be influenced by a series of factors. The degree to which these factors are observed at Company Alpha is shown below.

T A B L E 25

FACTORS AFFECTING OR/MS SUCCESS AT COMPANY ALPHA

	Rating
CONTROLLING	
- Level of Top Management Support	P
- Level and Nature of Sponsorship	P
- Level of Systems Development	M
- Availability of Computer Support	P
ASSISTING	
- Influence and Reputation of OR/MS group	M
- Relevance and Success of Projects	P
- Formalization of Procedures	M
- Level of Client Receptivity	M
- Nature and Competence of OR/MS personnel	P

Key: P = Pronounced; M = Moderate; N = Negligible

B. RESULTS OF THE FIELD STUDY IN COMPANY BETA

Company Background

Company Beta is one of the largest clothing manufacturers in South Africa. The company has been in existence for over thirty years but only really started to develop in the mid 1960's. This was a time of rapid growth by acquisition and Company Beta trebled its turnover between 1965 and 1969. Subsequent growth has not been as spectacular but a steady increase in sales and profit has been achieved since 1969. The company is quoted on the Johannesburg Stock Exchange and the following profit figures are given for Beta between 1969 and 1974.

TABLE 26

PROFIT PERFORMANCE FOR COMPANY BETA*

Year ending June 30th	1968	1969	1970	1971	1972	1973
Profit before Tax (R000)	1 250	1 320	1 430	1 410	1 470	1 525

*Source: Company Records

Group turnover in 1974 was R17 million and this figure is consolidated for six subsidiary companies.

Company Beta employs over 2 000 people and has factories located in Johannesburg, Durban and Cape Town. The geographical dispersion of the factories is as a result of the way in which the acquisitions were made. Although the Head Office is in Durban, the largest showroom and sales centre is in Johannesburg.

Beta has one or two international franchises but does not really have access to overseas expertise apart from areas such as sewing and design. The directors of Beta travel fairly regularly to fashion conferences in Europe, Britain and America, however they do not come into contact with any form of OR/MS activity on these trips.

History of OR/MS Activity

Company Beta maintains a permanent OR/MS activity in its Durban Head Office. The activity is generally referred to as the "Planning Group" and was created in 1970 as a special projects department to handle assignments pertaining to the whole organization. Beta has a very small Head Office staff as the Managing Directors of the various companies making up Beta still retain most of their decision-making authority.

The Planning Group was created by the Chairman of Beta to handle assignments which had to be tackled by some sort of centralized body. The Group is headed by a 32 year old Planning Manager, who was originally the Chief Accountant in one of the Beta subsidiaries, and two assistants. All three have been employed by Company Beta for over five years.

The Planning Group was not given any specific terms of reference by the Chairman who instructed them to work on projects which would result in an improvement of the operating performance of the six Beta subsidiaries as a whole. The first project tackled was co-ordinated buying. It was hoped that this would

result in greater quantity discounts being achieved by Beta. Unfortunately due to the fashion requirements of the subsidiary companies it was not possible to do very much more than achieve the co-ordination of the purchasing of cottons and sewing machines. However the project did allow the Planning Group members to meet the senior management of the various companies.

At the beginning of 1971 the group started on two major projects. The first was the rationalization of the selling activities of all six group members and involved the creation of a large marketing model of the consolidated companies in terms of styles, outlets, representatives and agents. In view of the large number of outlets and the complexity of the styles it was necessary to computerize the model. Beta did not have its own computer as individual companies did most of their data processing using different Bureaux. The Planning Manager worked on the computerization with a bureau that he had used before. The marketing model was complete by the end of 1971 and a series of reports were presented by the Planning Group during 1972. At the time of the field study (February 1974) no real progress had been made with the rationalization.

In mid 1971 the group also started the development of a Long Range Planning model for Beta using a five year forecast and a PROSPER modelling package from ICL. Individual companies were required to submit five year projections which were updated each year. At the time of the study the variances from target were still too great to make the model useful.

Top Management Profile

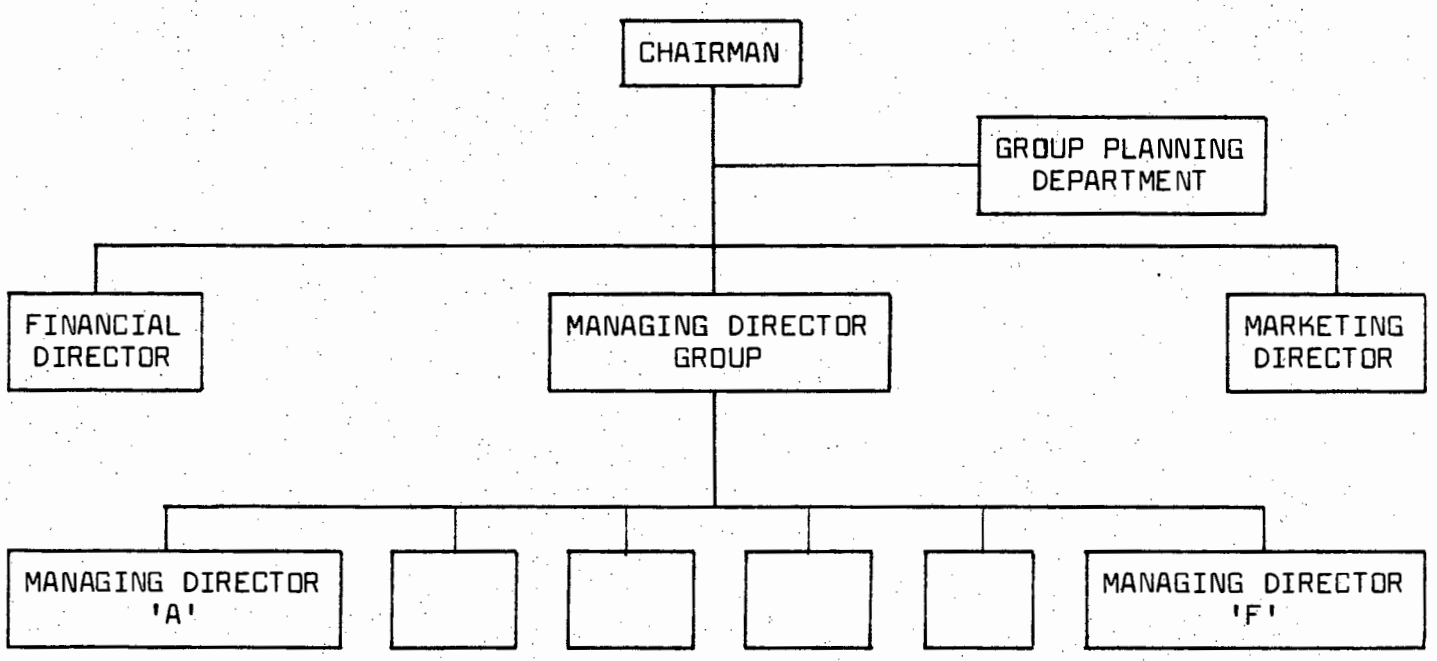
As a result of the manner in which Company Beta was formed during the period 1965 to 1970 there are theoretically about ten individuals who could be considered to represent Top Management. Two of the original Managing Directors of the subsidiary companies now occupy more senior positions, and the two newly appointed MD's are not involved in the day-to-day management of the conglomerate to any significant extent.

The present organization structure is shown in Figure 8. Although all the subsidiary companies have their own Accounts and Marketing Departments, the Financial Director and Marketing Director are supposed to provide overall control in these areas. The Group Managing Director is responsible for the co-ordination of the garment manufacturing process in the various companies.

Top Management of Beta is interesting as it comprises a group of entrepreneurs who were very successful operators of small companies which were each making a profit of approximately R250 000 in 1965. They are now running a much larger organization but many of their original attitudes have not changed. Beta remains a profitable, successful business and the management are fundamentally opposed to innovation, although from time to time they have tried to introduce more modern management techniques. Table 27 gives brief details of the various members of the Top Management team.

F I G U R E 8

PARTIAL ORGANIZATION STRUCTURE OF COMPANY BETA



T A B L E 27

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT

OF COMPANY BETA (28.2.1974)

Chairman (55) B.Comm. Started Beta in 1954 as a small factory, after ten years as a factory manager in another company. Has maintained controlling interest in Beta, and is responsible for the majority of acquisitions.

Marketing Director (60) Has worked for forty years in the clothing industry. Was Managing Director of the largest company acquired by Beta; has experience in all forms of clothing production.

Marketing Director (37) Joined Company D in 1960 and at the time of the acquisition was Joint MD with the founder who has since retired. He specialises in arrangement of large orders with chain stores.

Financial Director (35) CA (SA). Joined Beta in 1967 after completing articles. Has no clothing experience but a very competent financier.

Managing Directors A, B, E, F (40-59) Merged with Beta during 1965-1970. No formal qualifications, still run their companies.

Managing Directors C, D (37, 42) Appointed after existing MD's moved to higher positions. Both have CA qualifications.

Planning Manager (32) CA (SA). Has been in charge of the group since 1970. Previously chief accountant in Company A.

ANALYSIS OF COMPANY BETA

OR/MS Life Cycle

It is difficult to establish precisely at what point the Planning Group stands in the OR/MS Life Cycle. It was created by the Managing Director in an Externally Induced Process and was allocated personnel and resources. As it has not as yet really completed a project successfully it is still on Trial and therefore remains in the Introductory Phase.

Primary and Secondary Process

The Planning Group has still to complete a project, however, as Top Management has committed funds and resources to the group it has made the decision to test the group. The Primary Diffusion Process was complete in 1970 but the Secondary Process is still in its early stages.

Sponsorship

The only possible sponsor of the Planning Group is the Chairman and yet at no time has he appeared to be committed to the success of the Group. He has not used the Group to enhance his fortunes and in fact appears to be unaware of the activities of the Group.

PRIMARY PROCESS

Receptivity of Top Management

The low Receptivity rating of the various members of the Top Management of Beta highlight the reasons for the limited success of the projects backed by the Group. This rating indicates that the Top Management of Beta are not particularly enthusiastic about the Planning Group. It is interesting to note that the receptivity of the younger members of Top Management is much higher than the Receptivity of the older enterpreneurs. Furthermore the Chairman, who has acted as the sponsor, is not committed to OR/MS.

Overdone

see next page

T A B L E 28

RECEPTIVITY OF TOP MANAGEMENT OF COMPANY BETA TOWARD OR/MS

Top Manager		% Receptivity
Chairman	(55)	I
Managing Director	(60)	I
Financial Director	(35)	S
Marketing Director	(37)	I
MD Company A	Ages?	I
MD Company B		H
MD Company E		H
MD Company F		I
MD Company C	(37)	S
MD Company D	(42)	S
Planning Manager	? (32)	

Table 29 shows that Company Beta has very few of the Controlling Facilitating factors required to increase the Receptivity of Top Management towards OR/MS. In addition, the low Overall Information Systems Rating shows that Top Management has neglected the development of systems in Beta. This is in agreement with their low Receptivity for Innovation. The relatively high Receptivity of the Financial Director (S) is reflected in the equivalently well developed FOCIS system (0,78).

T A B L E 29

FACTORS AFFECTING RECEPTIVITY AT COMPANY BETA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	N
- Professionally trained Top Management	M
- Availability of EDP Expertise	N
ASSISTING	
- Top Management's exposure to Innovation	N
- Influence of Management Graduates	M
- Influence of International Consultants	N
- Use of OR/MS by Competition	M
- Increased Competition, Reduced Profits etc.	M
- Increased Size of Operation	P
- Government Involvement	N

T A B L E 30

INFORMATION SYSTEMS RATING IN COMPANY BETA

LOCIS System	=	0,35
PAOCIS System	=	0,63
FOCIS System	=	0,73
MOCIS System	=	0,28
Overall ISR	=	0,40

SECONDARY PROCESS AT COMPANY BETA

The Secondary Diffusion Process describes the process of the ultimate adoption of the innovation by both Top Management and subordinates within the organization. Although Top Management may adopt the innovation and decide to introduce it into the organization, the Secondary Process is not complete until subordinates in

the company confirm the adoption. Alternatively subordinates may reject the innovation and so force Top Management to discontinue it. In order to achieve adoption by Top Management and subordinates it is critical that the projects carried out by the OR/MS Group are successful.

Company Beta is an example of a situation in which Top Management of the company are still awaiting the outcome of a successful Trial before making the decision to adopt OR/MS. The data in Table 31 indicates that after 4 years Top Management are still not convinced that OR/MS offers any advantages to the Company.

T A B L E 31

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT BETA

	Co-ordinated Buying	Marketing Model	Long Range Planning
Chairman	M	N	U
Managing Director	M	S	N
Financial Director	N	N	M
Marketing Director	F	S	U
MD Division A	F	F	U
MD Division B	N	U	U
MD Division C	M	U	U
MD Division D	N	U	U
MD Division E	U	U	U
MD Division F	U	F	U

The table shows that generally the Top Management of Beta do not believe that the activities of the Planning Group have been particularly successful. In addition many of the members of Top Management have not made an attempt to try to understand what the

Planning Group is doing. Neither the Managing Director, nor the Chairman appear to be enthusiastic about the Planning Group.

In order to test the limited Success of the Group it is necessary to examine the factors which are believed to influence OR/MS success. These are listed in Table 32.

T A B L E 32

FACTORS AFFECTING OR/MS SUCCESS AT COMPANY ALPHA

	Rating
CONTROLLING	
- Level of Top Management Support	M
- Level and Nature of Sponsorship	N
- Level of Systems Development	M
- Availability of Computer Support	N
ASSISTING	
- Influence and Reputation of OR/MS Group	N
- Reference and Success of Projects	M
- Formalization of Procedures	N
- Level of Client Receptivity	N
- Nature and Competence of OR/MS Personnel	P

C. RESULTS OF THE FIELD STUDY IN COMPANY GAMMA

Is the parent overseas?

Company Background

Company Gamma is an importer and distributor of earth-moving and diesel equipment. A major facet of the business is the provision of service and spares. The company has been established in South Africa for the past fifteen years and initially made unsatisfactory progress. Although profits still fluctuate significantly from year to year the company has established itself successfully and has achieved a significant share of the market. Company Gamma is a division of a larger organization which is quoted on the Johannesburg Stock Exchange. The following turnover and profit figures were achieved by Gamma between 1971 and 1974.

TABLE 33

PROFIT AND TURNOVER PERFORMANCE FOR COMPANY GAMMA*

Year ending December 31	1971	1972	1973	1974
Turnover (R000)	2 960	3 806	4 952	6 321
Profit before Tax (R000)	28	185	482	575

*Source: Company Records

Company Gamma has a Head Office in Cape Town and has branches in most of the major industrial areas of the Republic. The company employes about 700 people most of whom are located in Johannesburg and Cape Town. Although Gamma is not controlled by its parent company, there is none the less a significant

interchange of expertise. Gamma personnel visit the US and Europe three or four times each year and there are regular visits from principals.

The company has an in-house computer installation which is staffed by a Data Processing Manager and three systems analysts/ programmers. Virtually all financial and production information systems have been computerized and the reporting systems operating in Gamma are extremely efficient.

History of OR/MS Activity

There is no formal OR/MS activity in Gamma. The company does however maintain a spares and service division at its Head Office. The duties of the Spares and Service Manager are to ensure that adequate inventory levels are maintained at all branches and that service carried out on plant is efficient and prompt.

Gamma maintained a spares and service department from its inception. However availability of spares declined whilst investment in spares increased. In 1969 the overall stockturn on spares was 0,72 which was a long way from the target of 3,0 per annum. Because of the lack of spares, service was bad and the company was loosing customers. At the end of 1969 the Financial Director of Gamma requested that spares and service department should be transferred from the Sales Division and made to report to him. Although this was resisted by the Sales Division the situation was so drastic that the change was made.

In January 1971 Gamma recruited a Parts Manager from a competitor. His task was to improve turnover, increase service on spares, and implement an effective scheduled maintenance scheme for Gamma customers. The Parts Manager hired two of his assistants from his previous employer and requested that one of the older and experienced mechanics be seconded to his department. At this stage the department strength had increased to seven but only four people were involved in the parts control exercise.

In June 1972 the Parts Manager of the parent company visited South Africa and recommended that consultants be employed to implement a computerized ordering and forecasting stock control system. The consultants worked at Gamma for a year and by January 1973 stockturn had reached 2,9 per annum, service on spares was up to 96%, and the scheduled maintenance programme was operating in all branches.

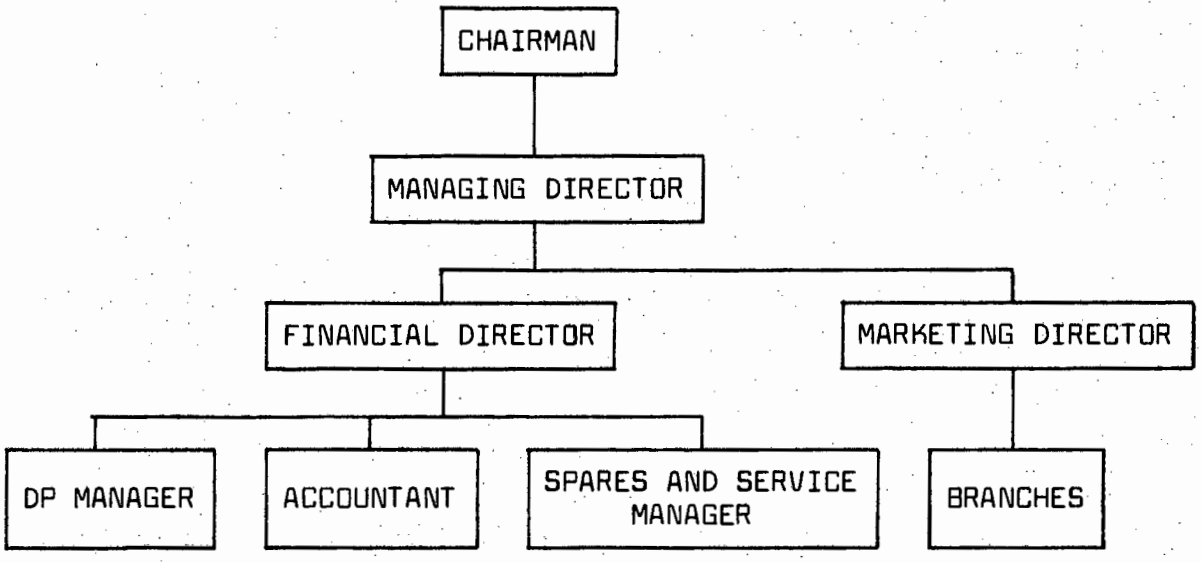
In November 1973 the Financial Director, the Parts Manager and the Data Processing Manager started to work on the introduction of on-line parts system which would control parts at all branches. The system was designed to seek parts in branches and to generate indents for replacement stock. Ultimately it was hoped that the system would also schedule workshop jobs based upon parts availability.

Top Management Profile

The Top Management team at Gamma is small and extremely competent. The field study carried out at Gamma was interesting because of the enthusiasm displayed by all members of Top Management for possible improvements to the spares and service systems.

F I G U R E 9

PARTIAL ORGANIZATION STRUCTURE OF COMPANY GAMMA



The organization chart does not show that although the Marketing Director controls the various branches throughout the Republic, the Spares and Service Manager has direct control of the spares and service departments in the branches. This is as a result of the old system and causes problems from time to time.

Brief biographical details of the various members of Top Management are given in Table 34.

TABLE 34

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT OF COMPANY GAMMA (31.7.1974)

Chairman (58) Chairman of the Board of the Holding Company. Has delegated all decision-making to the Managing Director of Gamma.

Managing Director (45) B.Sc. (Mec. & Civil). Appointed as Managing Director in 1965. Originally the general manager of another subsidiary. Travels overseas extensively, and has been responsible for the majority of innovations introduced at Gamma.

Financial Director (38) CA (SA) CWA. Joined the company out of articles as an accountant. Promoted to Financial Director in 1968. Responsible for the introduction of EDP at Gamma.

Marketing Director (40) Originally a competitive salesman. Joined Gamma in 1962 and was made Sales Manager in 1965 and Director in 1968. Vast knowledge of earthmoving equipment.

Spares and Service Manager (40) B.Comm. Eighteen years in parts control, eleven in earthmoving equipment. Joined Gamma in 1971.

Data Processing Manager (32) Joined NCR after school, moved to Gamma as senior programmer in 1968 when computer was installed. Made DP Manager in 1970.

Accountant ?

ANALYSIS OF COMPANY GAMMA

OR/MS Life Cycle

The Spares and Service Control Group is an integral part of the operation of Gamma. OR/MS began in Gamma in 1971 as an Externally Induced Process with the acquisition of the Spares Manager. The Introductory Phase lasted approximately one year and then moved to the Transitional Phase in 1972 when consultants were hired to implement a more sophisticated system. The OR/MS activity proved to be extremely effective. The "on-line" project

represents the next OR/MS activity.

Primary and Secondary Process

The Top Management of Gamma went through the Primary Diffusion Process in 1970 prior to the acquisition of the Spares Manager. At this time the Financial Director made the decision to introduce specific stock control techniques to improve the stock holding at Gamma. The Secondary Process started in 1971 and was complete with the success of the computerized stock project in early 1973.

Sponsorship

The Financial Director of Gamma emerges as the sponsor of OR/MS from its inception in 1970 until the present. By adopting the spares department and using it to progressively improve stockturn and service he ensured the success of the project and the complete adoption of OR/MS.

PRIMARY PROCESS AT COMPANY GAMMA

Receptivity of Top Management

The ratings in the following table clearly indicate that the Top Management of Gamma is totally committed to innovative activities such as OR/MS. The Marketing Director is not as favourably disposed to change but in view of the attitude of the three other members of Top Management this is not serious.

T A B L E 35

RECEPTIVITY OF TOP MANAGEMENT OF

COMPANY GAMMA TOWARDS OR/MS

Top Manager	% Receptivity
Chairman	E
Managing Director	E
Financial Director	E (sponsor)
Marketing Director	S

Why only 4 of 7 ?

The high Receptivity Rating is confirmed by the analysis of the factors affecting Receptivity.

T A B L E 36

FACTORS AFFECTING RECEPTIVITY AT COMPANY GAMMA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	M
- Professionally Trained Top Management	P
- Availability of EDP Expertise	P
ASSISTING	
- Top Management exposure to Innovation	M
- Influence of Management Graduates	N
- Influence of International Consultants	P
- Use of OR/MS by Competitors	M
- Increased Competition, Reduced Profits, etc.	M
- Increased size of Operation	M
- Government Involvement	N

The effect of the work performed by the Financial Director on systems development in Gamma is clearly visible in Table 37.

T A B L E 37

INFORMATION SYSTEMS RATING IN COMPANY GAMMA

LOCIS	System ISR	= 0,71
PAOCIS	System ISR	= 0,87
FOCIS	System ISR	= 0,93
MOCIS	System ISR	= 0,71
OVERALL ISR		= 0,82

SECONDARY PROCESS AT COMPANY GAMMA

There are only three projects at Gamma which could be considered OR/MS. They are the Stock Control project, the Scheduled Maintenance project, and the on-line Inventory Control project. Of the three the first two are virtually complete and the latter is still being developed.

T A B L E 38

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT GAMMA

Manager	Inventory	Maintenance	On-Line
Chairman	S+	S	U
MD	S+	S+	M
Financial Director	S+	S	S
Marketing Director	M	S	U

It is interesting to test the factors influencing success to find whether equivalently high ratings are obtained.

T A B L E 39

FACTORS INFLUENCING SUCCESS AT COMPANY GAMMA

	Rating
CONTROLLING	
- Level of Top Management Support	P
- Level and Nature of Sponsorship	M
- Level of Systems Development	P
- Availability of Computer Support	P
ASSISTING	
- Influence and Reputation of OR/MS Group	M
- Relevance and Success of Projects	P
- Formalization of Procedures	M
- Level of Chart Receptivity	M
- Nature and Competence of OR/MS Personnel	P

D. RESULTS OF FIELD STUDY IN COMPANY DELTA

Company Background

Company Delta is a departmental store chain that has forty-five branches in the Transvaal, Free State, and Northern Cape. Delta was founded in Potchefstroom after the First World War and has expanded hesitantly in the intervening sixty years. The performance of Delta has varied significantly from year to year and there has never been a five year period that has shown increasing turnover and profits. The company is quoted on the Johannesburg Stock Exchange and is a subsidiary of a large South African financial house. The turnover and profit record of Company Delta are as follows:

TABLE 40

TURNOVER AND PROFIT RECORD OF DELTA*

Year ending December 31st	1969	1970	1971	1972	1973	1974
Turnover (R000)	na	na	na	13 120	15 350	14 272
Profit after Tax (R000)	-26	350	-90	85	80	70

*Source: Company Records

Although the company is not family controlled the majority of the Top Management team have been with Delta for over twenty years. The company has no access to overseas expertise as there are no international associations whatsoever. Company Delta buyers visit Europe and Britain each year but this is not a source of information regarding innovative developments.

History of OR/MS Activity

Company Delta does not have a formal OR/MS activity, however the Merchandising Division employs a statistician who has been involved in the development of a model of the merchandising patterns observed in the various branches of Delta since 1972.

This OR/MS activity was created by the Merchandising Director who joined the company in 1971, replacing the previous Director who resigned after twenty-five years service. His resignation coincided with the R90 000 loss recorded by Delta in 1971. In view of the total absence of any merchandising and stock information the incoming Director introduced an integrated stock/merchandising record and control system to provide the data base for the more efficient running of his department. In February 1972 an OR/MS analyst was hired to analyse the data and to produce a Merchandising-Forecasting system which would be used to provide buyers with meaningful information on trends and sales patterns.

The analyst spent the following eighteen months introducing the paper work systems which were required to support the information systems. Due to personality problems that arose between the Merchandising Director and the remainder of Managers in the organization, particularly the Operations Director, the implementation of the system at store level was extremely difficult.

The processing of the paper work associated with the proposed merchandising and stock system created additional problems for the OR/MS analyst. Prior to 1972 Delta had used an outside computer bureau for processing monthly salaries; all other systems were manual. Although it was relatively easy to find a bureau that was capable of handling the project, it took a great deal of effort to get documentation in from the branches on time.

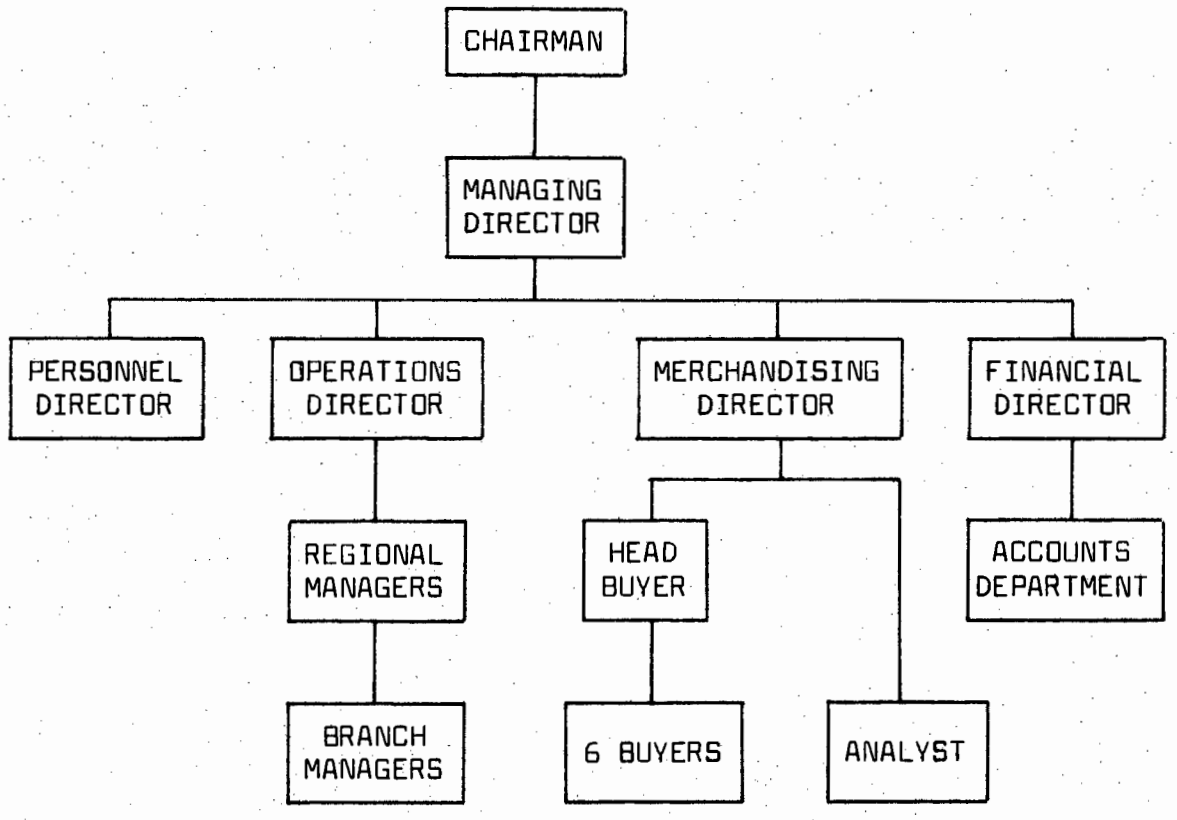
By July 1974, when the field study took place, the system was still not operational. The difference between actual and theoretical stocks was too great to be accepted, buyers refused to accept Merchandising returns because of the incidence of negative stockholdings on the reports, and the turnaround on the reports varied from three to six weeks after month end.

Top Management Profile

The most striking thing about the Top Management of Delta is the fact that the executive team, with one exception, has been employed by the company for over fifteen years. Some have worked for Delta since leaving school and have no experience of any other business environment. The key executive positions at Delta are shown in Figure 10.

F I G U R E 10

PARTIAL ORGANIZATION STRUCTURE OF COMPANY DELTA



Delta was originally family controlled, and the previous Chairman, who was the last family member involved, retired in 1970. His retirement coincided with the acquisition of a controlling interest in Delta by a large South African financial house. The present Chairman is an appointee of the holding company. He is an extremely competent financier with little knowledge of retailing.

Brief biographical details of the various members of Top Management are given in Table 41.

T A B L E 41

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT

AT COMPANY DELTA (12.10.1974)

Chairman (62) CA (SA). Joined Delta as Chairman in 1970. Appointed by Holding Company.

Managing Director (60) Has been with Delta for over forty years, progressing from Manager at Bloemfontein branch to Operations Director, appointed MD in 1965.

Personnel Director (48) Originally worked for Iscor, has been with Delta since 1950.

Operations Director (55) Thirty five years experience with Delta. Previously Branch Manager, became Operations Director in 1965.

Financial Director (58) CA (SA). Was originally a partner in the firm of auditors who work at Delta. A personal friend of the MD. Joined Delta as Financial Director in 1958.

Merchandising Director (42) B.Com. Joined Delta in 1971 from a large retail chain where he had been Chief Buyer. About 20 years merchandising experience.

Chief Buyer (57) He has worked at Delta since leaving school and has been a buyer for fifteen years. Made Chief Buyer in 1969.

ANALYSIS OF COMPANY DELTA

OR/MS Life Cycle

OR/MS activity at Company Delta is still very much in the Prebirth Phase. The Merchandising Director employed a statistician in 1972 and both have been trying to introduce merchandising systems for the past two years. Apart from sanctioning the recruitment of the statistician, the Top Management of Delta are not involved in the merchandising project and are not interested in it. Theoretically the merchandising

project could be called the Trial period of the Introductory Phase. However the remainder of Top Management do not appear to be aware that the Merchandising Director is testing a new approach to merchandising, and as a result it would appear that this is the Prebirth Phase. If Top Management do subsequently agree to a formal Trial OR/MS, this will then be an Internally Induced Process.

Primary and Secondary Process

The Top Management of Delta appear to have reached the Awareness Phase of the Primary Process of OR/MS diffusion. The Top Management of the company may become interested and decide to make a trial of the merchandising project, thus completing the Primary Process and starting the Secondary Process.

Subordinates in the organization have already rejected OR/MS because they have realized that Top Management is not interested in the project. This may eventually force the Merchandising Director to abandon the exercise.

Sponsorship

The Merchandising Director emerges as the sponsor of the OR/MS activity. Unfortunately he lacks many of the requirements of an effective sponsor. He does not have Top Management support, he has not been able to allocate anyone beyond a single individual to the project and he does not have the necessary status within the organization. Due to the apathy displayed by members of Top Management it has not been possible to get commitment from

subordinates in the organization. Neither the Merchandising Director nor the OR/MS analyst have been able to get branch managers to participate in the exercise.

PRIMARY PROCESS AT COMPANY DELTA

Receptivity of Top Management

The Receptivity Ratings of the various members of Top Management of Delta are given in Table 42. The majority of the Delta directors are totally opposed to innovation.

T A B L E 42

RECEPTIVITY OF TOP MANAGEMENT OF COMPANY DELTA TOWARDS OR/MS

Top Manager	Receptivity
Chairman	S
Managing Director	H
Personnel Director	H
Operations Director	I
Merchandising Director	S (sponsor)
Head Buyer	H
Financial Director	H

The relatively low rating of the sponsor highlights one of the most serious problems that face the entire merchandising project. The Merchandising Director does not really have adequate knowledge of the implication of the changes that he is trying to introduce. Neither he nor his assistant are aware of the degree to which the systems at Delta will have to be redefined to support

the Merchandising Information System.

It is not difficult to explain the low Receptivity Ratings of Delta Top Management. Table 43 lists the scoring for the factors believed to influence Receptivity and these confirm that Delta is an unfortunate environment in which to establish OR/MS. The Information Systems Ratings shown in Table 44 also highlight the inadequate systems development in Delta.

T A B L E 43

FACTORS AFFECTING RECEPTIVITY IN COMPANY DELTA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	N
- Professionally Trained Top Management	N
- Availability of EDP Expertise	N
ASSISTING	
- Top Management exposure to Innovation	N
- Influence of Management Graduates	N
- Influence of International Consultants	N
- Use of OR/MS by Competition	N
- Increased Competition, Reduced Profits	P
- Increased Size of Operations	N
- Government Involvement	N

T A B L E 44

INFORMATION SYSTEMS RATING IN COMPANY DELTA

LOCIS	System =	0,35
PAOCIS	System =	0,13
FOCIS	System =	0,33
MOCIS	System =	0,28
OVERALL ISR	=	0,29

SECONDARY PROCESS AT COMPANY DELTA

It is hypothesised that the Secondary Diffusion Process of OR/MS is significantly influenced by the success of OR/MS activities. This means that OR/MS is likely to be more readily adopted by subordinates and Top Management if the projects attempted by the OR/MS group are seen to be relevant and successful.

In the case of Company Delta, the Secondary Process has not started as Top Management have not decided to embark on a Trial of OR/MS. The attitudes of the Merchandising Director and his assistant are not representative of Top Management's attitude to the merchandising project. Generally the Top Management of Delta are unaware of what the project is designed to achieve, or have already rejected it as a failure. This is shown clearly in Table 45 where a Rating of U denotes "Uncertainty" and F is "Failure". This confirms that Top Management of Delta have barely reached the Awareness/Interest Phase of the Primary Diffusion Process and the Secondary Process has not started.

T A B L E 45

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT DELTA

	Merchandising/ Stock Project
Chairman	U
Managing Director	U
Personnel Director	U
Financial Director	U
Merchandising Director	S
Chief Buyer	F
Operations Director	F

This shows that Top Management at Delta are either deliberately or by accident unaware of the implications and progress of the exercise.

As the Primary Process is not complete these ratings of success are not very meaningful. However Table 46 shows very clearly that it is extremely unlikely that the merchandising project is going to progress satisfactorily even if Top Management do become involved.

T A B L E 46

FACTORS AFFECTING OR/MS SUCCESS AT COMPANY DELTA

	Rating
CONTROLLING	
- Level of Top Management Support	M
- Level and Rating of Sponsorship	N
- Level of Systems Development	M
- Availability of Computer Support	N
ASSISTING	
- Influence and Reputation of OR/MS Group	M
- Relevance and Success of Projects	N
- Formalization of Procedures	M
- Level of Client Receptivity	N
- Nature and Competence of OR/MS Personnel	M

E. RESULTS OF FIELD STUDY IN COMPANY EPSILON

Company Background

Company Epsilon is a financial investment house which ranks as one of the four biggest in South Africa. The company was formed shortly after World War II and has grown steadily since its foundation. During this time the accent of Epsilon has changed significantly and it has developed controlling interests in some of the larger South African businesses. The company is quoted on the Johannesburg Stock Exchange and has long been regarded as a well-run conservative company. Performance figures for the group are given in Table 47. Gross income of Epsilon is normally not disclosed but was estimated to be in excess of R310 million in 1973.

TABLE 47

PROFIT PERFORMANCE FOR COMPANY EPSILON*

Year ending December 31st	1969	1970	1971	1972	1973
Profit before Tax (R000)	36 252	39 381	40 082	39 972	58 842

*Source: Company Records

Company Epsilon has offices in all the major centres of South Africa and maintains a staff of approximately 850 people. Epsilon's investments are geographically distributed throughout South Africa with a concentration in the Pretoria-Witwatersrand Triangle.

Although Epsilon itself is not overseas controlled many of its investments are with international partners. The majority of these partners are German, Dutch and English. Generally Epsilon has the controlling interest in these investments but technical expertise and control systems are usually supplied by the partner. Directors of Epsilon visit Europe and America regularly whilst many of the executives of the international partners visit the Republic routinely. Epsilon has access to a great deal of OR/MS expertise as the majority of her investments are in high technology industries with well developed OR/MS ability.

History of OR/MS Activity

In July 1970 company Epsilon appointed an international firm of Management Consultants to examine the entire organization, its structure, its personnel, and its systems. This study took until November 1972 to complete and was far broader in concept than originally anticipated. Within two months of their arrival the consultants recommended the creation of a formal Integrated Planning Group for the control of the budgetting and planning of the fifty odd investments which Epsilon had in South Africa at the time. The consultants felt that although specific individuals in Epsilon were delegated the responsibility of supervising and reporting on various investments there was no overall co-ordinating control.

The Integrated Planning Group was formed in November 1970. Initially it was staffed by four people. The Manager was

previously an Investment Officer in Epsilon responsible for the control of three or four investments. In addition there was a female statistician, a young Chartered Accountant seconded from the Epsilon Financial Department, and one of the consultants who had specialised in Financial Forecasting. The Group's first project was the design and implementation of a common financial forecasting procedure for all investments.

This project was well underway in June 1971 when the Group installed its own mini-computer system with two terminals. This system was designed to assist in the developing of forecasting models and the refinement of forecasts. Epsilon had its own ICL machine which was installed in 1964, but it was felt that the work of the Group would be more effective if they had their own computer. Epsilon's Data Processing Department consisted of a DP Manager and three systems analysts/programmers. One of the more experienced systems analysts, who had designed the Budget/Financial Reporting programmes, was seconded to the Integrated Planning Group to write the necessary programmes and work as a member of the group.

At the end of 1972, five-year forecasts for all investments and integrated five-year forecasts for the entire Epsilon Group were produced by the Integrated Planning Group. These forecasts were prepared by the management of the companies concerned and members of the planning group. The individual forecasts were extremely detailed showing profit/turnover projections, anticipated dividends, cash flows etc. and were used to make similar projections for Epsilon itself.

The forecasts were to be updated every six months, and the first revision took place in July 1973. However many subsidiaries were one to three months late with their half-year figures due to inadequate reporting systems. In addition it soon became obvious that many of the forecasts themselves were totally inaccurate. This finding was in agreement with that of the consultants who had detected a wide divergence of management competence in many of Epsilon's investments.

In January 1974 the Integrated Planning Group was assigned the task of redesigning the budgetting and control systems of 10 of the 52 Epsilon investments. These companies were responsible for nearly 35% of annual income, and were generally locally controlled.

Top Management Profile

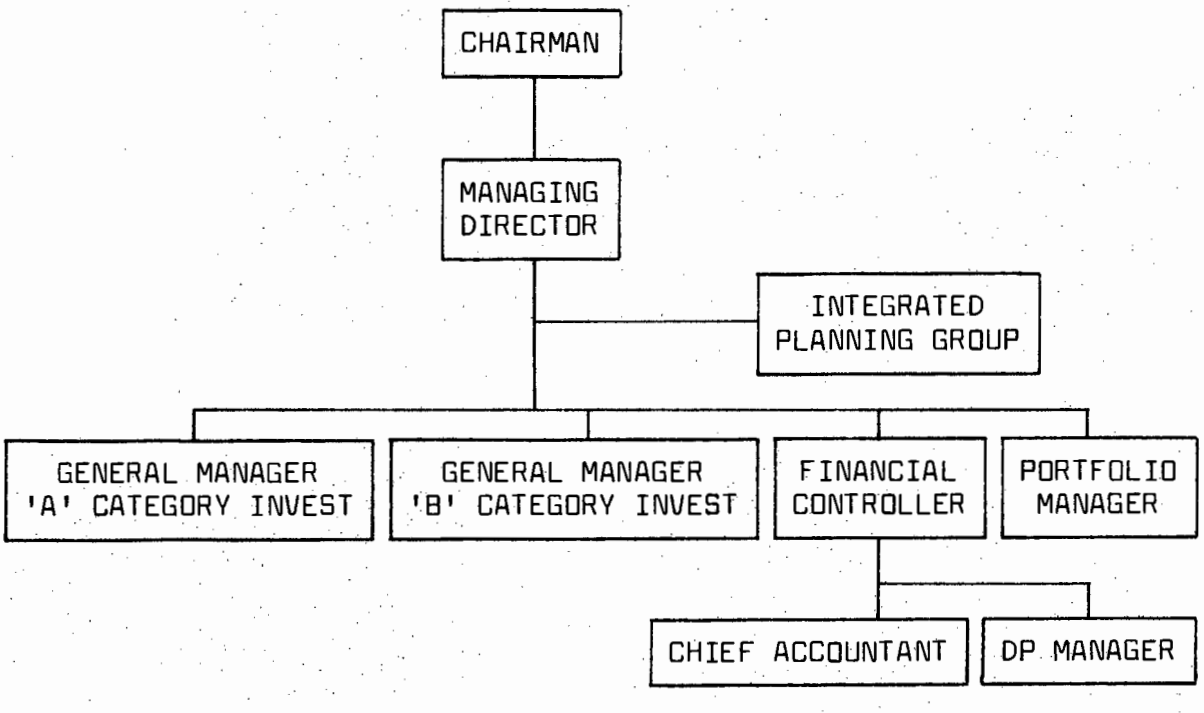
The organization chart of Epsilon was totally redesigned by the Management Consultants during 1970/1972. Although several new positions were established they were filled from within Epsilon or from one of the investments. The key Top Management positions are shown in Figure 11.

The General Managers of 'A' and 'B' category investments controlled between 5 and 10 Investment Managers who were each responsible for two to ten investments. These Investment Managers acted as communication channels between Epsilon and the investments and wielded very little authority. 'A' category investments were typically engineering companies whilst 'B'

category investments consisted of hotels, retailing chains, supermarkets etc.

F I G U R E 11

PARTIAL ORGANIZATION STRUCTURE OF COMPANY EPSILON (15.1.1974)



The Portfolio Manager of Epsilon handled the day-to-day cash management of the company. This function was very much dependent upon information gathered by the Integrated Planning Group for its cash management policies. At any point in time the Portfolio Manager would be responsible for between R2,5 to R7,0 million.

The following table gives brief biographies of the members of the Top Management Team at Epsilon.

T A B L E 48

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT

AT COMPANY EPSILON (15.1.1974)

Chairman (52) CA(SA) CWA. Joined Epsilon when it was founded as Chief Accountant, promoted to General Manager (1960), Managing Director (1963) and Chairman (1968). Board member of many leading SA companies.

Managing Director (45) B.Comm., LL.B. Originally legal advisor to one of Epsilon's investments. Appointed General Manager of 'B' Investments Division in 1963 and became Managing Director in 1968.

Financial Controller (46) CA(SA), MBA. Completed his articles in 1954 and worked for a bank for ten years. Recruited as financial controller for Epsilon in 1964.

Portfolio Manager (39) Trained on the J.S.E. 1958 to 1960. Partner in broking firm until 1965. Joined Epsilon as Assistant Portfolio Manager 1966 and became Manager in 1972 when previous Manager retired.

General Manager 'A' Investments (44) B.Sc. (Elec. & Mech.) Originally a consulting engineer with Escom for eight years. With Epsilon since 1962, first as an Investment Manager and as a General Manager since 1970.

General Manager 'B' Investments (39) B.Comm., CA. Accountant in a hotel group acquired by Epsilon in ~~1965.~~ ~~Became~~ General Manager in 1969.

IPG fits where?

ANALYSIS OF COMPANY EPSILON

OR/MS Life Cycle

The Integrated Planning Group was created in 1970 as a formal part of the organizational structure on the basis of the consultant's recommendations. It would appear that the OR/MS activity started in its Transitional stage, if the classical OR/MS Life Cycle is considered. This however is not quite

accurate, as the Financial Department of Epsilon had been trying to improve the standard of Financial Forecasting of the holding company for several years. A five year forecast was produced each year which turned out to be of little value in view of the lack of communication between the Financial Department of Epsilon and the various investments.

This period, prior to 1970, can therefore be considered as a Prebirth stage during which the Management of Epsilon were Aware of and Interested in the possibility of improving the long term financial planning of the company. However Top Management did not appear to know how to go about improving the situation. The arrival of the consultants was enough to push the OR/MS group through the Introductory Phase of the Life Cycle into the Transitional Phase with adequate staff and financing being supplied by Top Management.

The purchase of the mini-computer confirmed Top Management's faith in the Integrated Planning Group. By December 1972 the Group was an integral part of Epsilon and had achieved Maturity. The failure of the Forecasting exercise in July 1973 did not adversely affect the status and credibility of the Group in any way. In fact it was instrumental in increasing the power of the Group.

? Why not?

Primary and Secondary Process

The Top Management of Epsilon passed through the Primary Process of OR/MS diffusion during 1965-1970 when Management started

to become interested in improved methods of forecasting and performance monitoring. The Secondary Process started once the Integrated Planning Group was formed in November 1970 and was complete by January 1973 when the reporting requirements of the Planning Group were within the operating instructions of all investments.

Sponsorship

No clear sponsor of OR/MS activity can be identified in Epsilon. However the Financial Department and the Portfolio section emerge as two committed users of the information produced by the Integrated Planning Group. Both have been extremely supportive of the Group and have used the Group to prove that many of the companies in which Epsilon has interests have poorly developed information systems.

PRIMARY PROCESS AT COMPANY EPSILON

Receptivity of Top Management

Although Epsilon is only involved in Financial Model Building and Forecasting at present the Receptivity of Top Management for OR/MS is surprisingly high.

T A B L E 49

RECEPTIVITY OF TOP MANAGEMENT OF COMPANY EPSILON

TOWARDS OR/MS

Top Manager	Receptivity
Chairman	S
Managing Director	S
Financial Controller	E
Portfolio Manager	S
GM 'A' Investments	E
GM 'B' Investments	S

The rating of Epsilon in terms of Factors affecting Receptivity is given in Table 50.

T A B L E 50

FACTORS AFFECTING RECEPTIVITY IN COMPANY EPSILON

	Rating
CONTROLLING	
- Influence of International Parent/Associate	M
- Professionally Trained Top Management	P
- Availability of EDP Expertise	P
ASSISTING	
- Top Management Exposure to Innovation	P
- Influence of Management Graduates	M
- Influence of International Consultants	P
- Use of OR/MS by Competition	M
- Increased Competition, Reduced Profits	N
- Increased Size of Operation	M
- Government Involvement	M

The work done by the consultants in Epsilon has resulted in the development of an extremely effective Information System in all areas.

T A B L E 51

INFORMATION SYSTEMS RATING IN COMPANY EPSILON

LOCIS	System	= 0,71
PAOCIS	System	= 0,75
FOCIS	System	= 0,85
MOCIS	System	= 0,85
OVERALL ISR		= 0,80

SECONDARY PROCESS AT EPSILON

Although the Financial Forecasting Project and the Integrated Financial Model are closely related to one another they are in fact two totally separate projects. The Integrated Financial Model depends upon the Financial Forecasting Model for input and as a result is only as accurate as the projections of the Forecasting Model. However the Integrated Financial Model does permit the Top Management of Epsilon to carry out sensitivity anlyses to determine the effect of varying returns from major investments. Top Management of Epsilon was therefore asked to rate the success of both projects independently.

Surprisingly enough the rating of both projects is Moderate Success or better, which shows that Top Management of Epsilon are aware of the reasons for the limited success of the

Financial Forecasting project. Discussions with Top Management indicated that the majority had already decided that the basic model was adequate and it was now necessary to ensure that the inputs from individual companies was meaningful.

T A B L E 52

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT COMPANY EPSILON

Manager	Financial Forecasting	Integrated Model
Chairman	M	S
Managing Director	M	S
Financial Controller	S	S+
Portfolio Manager	S	S+
General Manager 'A'	S	S
General Manager 'B'	S	S

The impact of the various factors influencing success at Epsilon are given in Table 53.

T A B L E 53

FACTORS AFFECTING SUCCESS AT COMPANY EPSILON

	Rating
CONTROLLING	
- Level of Top Management Support	P
- Level and Nature of Sponsorship	M
- Level of Systems Development	P
- Availability of Computer Support	P
ASSISTING	
- Influence and Reputation of OR/MS Group	P
- Relevance and Success of Projects	P
- Formalization of Procedures	N
- Level of Client Receptivity	N
- Nature and Competence of OR/MS Personnel	N

F. RESULTS OF THE FIELD STUDY IN COMPANY THETA

Company Background

Company Theta manufactures and markets men's and women's clothing. The company was founded in 1930 and grew slowly until 1962 when it merged with an organization of comparable size. Between 1962 and 1970 subsequent growth was very rapid and at the end of the boom period Theta was one of the largest clothing companies in South Africa. Growth brought problems of control with it and the profits of Theta varied considerably between 1968 and 1973. The company is quoted on the Johannesburg Stock Exchange and is still very largely family owned.

TABLE 54

PROFIT AND TURNOVER PERFORMANCE FOR COMPANY THETA*

Year ending Dec. 31st	1968	1969	1970	1971	1972	1973
Profit before Tax (R000)	365	480	57	-175	98	425
Turnover (R000)	14 650	15 800	16 210	14 920	15 200	16 850

*Source: Company Records

Company Theta has its Head Office in Durban and sales offices throughout South Africa. The company employs about 1 500 people, the majority in Durban and Cape Town. The company markets its products under a number of brand names, the majority of which are regarded as leading South African brands.

Theta manufactures three American brandnames under

licence. This has given the company access to American and European merchandising and production expertise. The majority of Theta executives visit their principals and Trade Fairs in Europe and America once or twice a year. Most of the Top Management of Theta are extremely conscious of the deficiencies of the company and many of the innovations introduced during the last few years stem from these visits.

History of OR/MS Activity

Company policy at Theta has been to insist on the development of effective information and planning systems within subsidiaries. As many of the companies acquired by Theta were family owned and managed, they generally used unsophisticated financial, marketing and production control techniques. These were allowed to remain until the Systems Development Group in Theta's DP division was able to implement new systems based upon company standards.

Theta acquired its own ICL computer in 1968 to handle routine data processing applications such as wages, debtors, and salaries. By 1970 the DP department had expanded its sphere of operations to include costing, inventory records (raw material, work in progress, and finished goods) and production scheduling. In order to do this for the member organisations of the group it was necessary to expand the systems analysis section of the DP department. In 1971 the Merchandisers of the larger companies approached the DP Manager to ask for an integrated Merchandising and Production Planning system which would accept booked orders as

input and produce a production schedule for each range based upon the availability of fabric. This would be rerun weekly during the production cycle of the range.

The Systems Development Group was created at this time (July 1971) as a special projects division within the Data Processing Department to handle this type of assignment. The Group was headed up by a senior systems analyst who had been with Theta since 1968. He had previously worked in a large men's clothing company in Cape Town designing production planning systems, and had nearly ten years experience in the clothing industry. In addition the Group had another systems analyst, a production manager from one of the factories, as well as several programmers. The Top Management of Theta decided to allocate additional personnel to the Group as and when required. To handle the merchandising assignment two junior merchandisers were seconded to the Group for a year.

The Merchandising/Production Planning project initially made rapid progress, but by September 1972 had bogged down in some firms because of fundamental systems differences. However it was working successfully in four companies by January 1973 and had been introduced into all member companies by the year-end.

In March 1973 the Systems Development Group started to design a Booked Orders System for the Marketing Division. Due to the short selling period of ranges, it was essential that projection on oversold and discontinued styles was as rapid as possible.

Working very closely with the marketing departments of the two biggest companies in Theta, the Systems Development Group completed and installed an acceptable system by early 1974. It was hoped to instal terminals in all sales offices of Theta to speed up data capture.

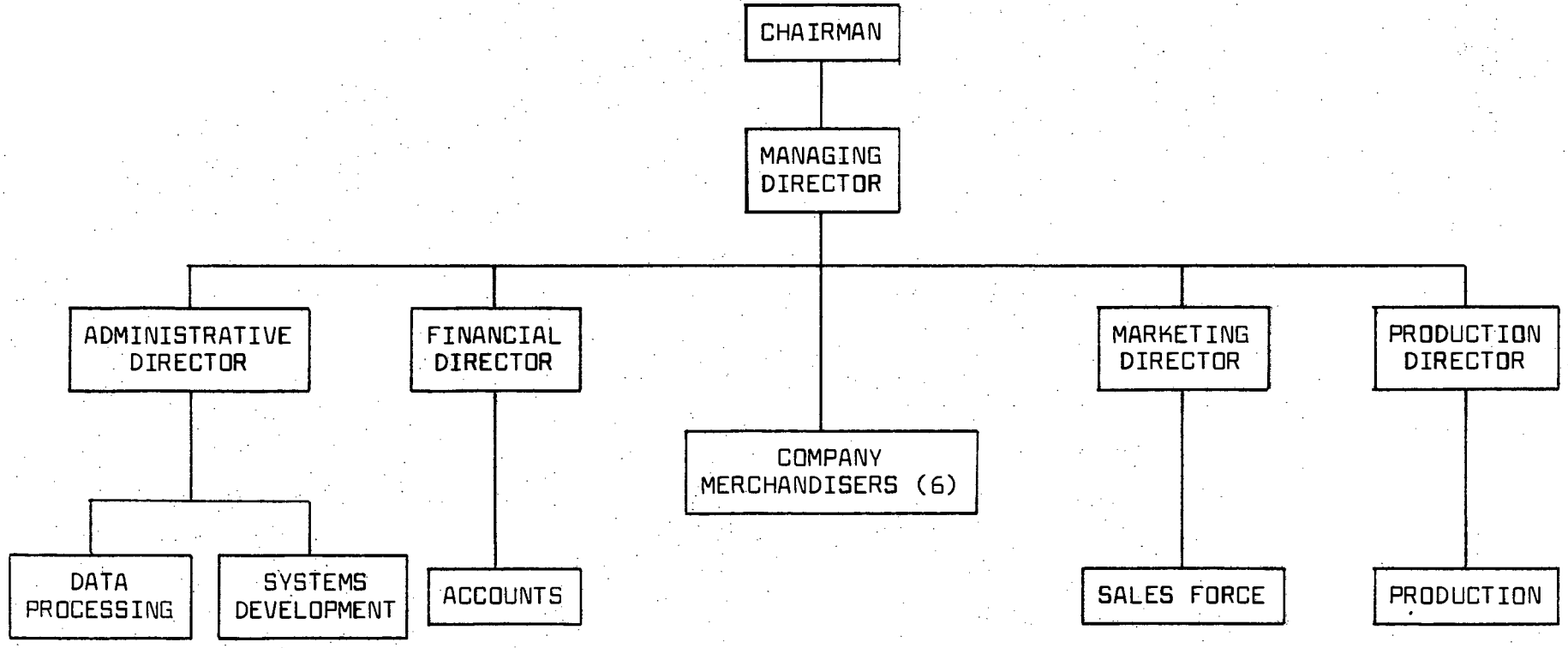
TOP MANAGEMENT PROFILE

Individual Managing Directors of companies which had been taken over by Theta during 1975-1970 were normally referred to as Merchandisers. When the field study was conducted in 1973 the organization structure of Theta was in a state of flux due to the proposed centralization of the majority of functions at Head Office. The new organization structure was designed to permit Merchandisers of companies to continue design and manufacture of sample ranges as they had in the past. These ranges would be carried by members of the Theta Sales team, and would be manufactured by a Theta Production Division under the control of a Production Director. All financial and administration functions would be centralized, but Merchandisers would still be responsible for the selection of fabric of their ranges. The proposed organization structure is shown in Figure 12. This was due to be implemented in January 1974.

F I G U R E 12

PROPOSED PARTIAL ORGANIZATION STRUCTURE OF

COMPANY THETA (PROJECTED 1.1.1974)



A brief resumé of the members of the Top Management team at Theta is given in Table 55. It must be borne in mind that although all the individuals were employed in Theta, they were not yet in the positions shown in the organization chart at the time of the field study. This organization chart came into being two months after the field study was completed.

T A B L E 55

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT OF COMPANY THETA

(13)

Chairman (64) Founder of Theta and majority shareholder. Over forty years experience in the clothing industry.

Managing Director (42) B.Comm.,CA (SA). Originally Financial Controller of Theta, which he joined after serving articles. Promoted to Managing Director in 1970 when position created for the first time.

Administrative Director (48) CIS. Currently Managing Director/ Owner of one of the companies acquired by Theta. Twenty years clothing industry experience.

Financial Director (35) CA (SA), CWA. Currently Financial Controller of one of Theta's subsidiaries, has held this position for over ten years.

Marketing Director (47) The Sales Director of Theta since 1965 with twenty-five years sales experience. Is regarded as one of the most knowledgeable men in Theta.

Production Director (38) ATI. Recruited by the Chairman in the UK in 1971. Was previously production manager of a large British clothing company. Has been responsible for control of production of two largest companies in Theta for two years.

6 Merchandisers (29-52) No formal qualifications. Have between ten and thirty years of experience in range selection and designing.

DP Manager (38) B. Comm. Joined Theta as DP Manager in 1968. Had five years experience in DP in the clothing industry prior to this.

ANALYSIS OF COMPANY THETA

OR/MS Life Cycle

The Systems Development Group is a formal part of the organization structure of Company Theta. It has been assigned personnel and is now engaged in setting up systems within Theta which will be adopted by all companies. However it does not have a permanent charter and it is likely that it may be disbanded once the majority of the systems are operational.

The period 1969-1971 seems to correspond to the Prebirth Phase of OR/MS activity in Theta, this was followed by the Introductory Phase from July 1971 to January 1973 when the Merchandising/Production Planning systems became operational in at least four companies. The Group has been in the Transitional Phase of the Life Cycle since early 1973. The success of the Merchandising/Production Planning projects and the Booked Orders systems do not appear to be sufficient to make Top Management grant a permanent charter to the Group.

Primary and Secondary Process

The Primary Diffusion Process of OR/MS at Theta started in 1969 and was complete in July 1971. The Secondary Process started with the introduction of the Systems Development in 1971 and was complete in 1972. Although the majority of Top Management and lower levels of Management appear to have adopted OR/MS, there are still members of Top Management who feel that the Group will have to be disbanded once the Booked Orders system is operational.

Sponsorship

The Data Processing Manager of Theta is the only individual who can be identified as a sponsor of the OR/MS activity. He was largely instrumental in obtaining sanction for the creation of the Systems Planning Group.

PRIMARY PROCESS AT COMPANY THETA

Receptivity of Top Management

The proposed reorganization of Company Theta will very much reduce the authority and responsibility of the managers of the six companies which were merged to form Theta. As a result, these individuals are not included in the determination of Top Management Receptivity.

TABLE 56

RECEPTIVITY OF TOP MANAGEMENT AT COMPANY THETA TOWARDS OR/MS

Top Manager	% Receptivity
Chairman	I
Managing Director	S
Admin. Director	S
Financial Director	S
Marketing Director	I
Production Director	S

Why 6 out of 13?

The most noticeable feature of the Receptivity of Top Management of Theta towards OR/MS is that it is low and that it does not vary significantly between individuals.

among

T A B L E 57

FACTORS AFFECTING RECEPTIVITY AT COMPANY THETA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	N
- Professionally Trained Top Management	M
- Availability of EDP Expertise and Support	P
ASSISTING	
- Top Management Exposure to Innovation	M
- Influence of Management Graduates	N
- Influence of International Consultants	N
- Use of OR/MS by Competition	M
- Increased Competition, Reduced Profits etc.	M
- Increased Size of Operation	M
- Government Involvement	N

The systems in Theta are fairly well developed due to the activities of the Systems Development Group. This is shown by the Information Systems Ratings which were recorded in Theta.

T A B L E 58

INFORMATION SYSTEMS RATING IN COMPANY THETA

LOCIS	System ISR =	0,71
PAOCIS	System ISR =	0,63
FOCIS	System ISR =	0,80
MOCIS	System ISR =	0,55
OVERALL ISR	=	0,70

SECONDARY PROCESS AT COMPANY THETA

The Systems Development Group at Theta has completed the Merchandising/Production system in all six subsidiaries and has partially completed the Booked Orders system. The Management ratings of the success of these projects is shown in Table 59.

T A B L E 59

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS OF THETA

Manager	Merchandising Project	Orders Project
Chairman	S+	U
Managing Director	S	M
Admin. Director	S	M
Financial Director	S+	S
Marketing Director	S	S+
Production Director	S+	S+

It is evident that although Top Management is not particularly receptive towards OR/MS they all feel that the two projects handled to date have been successful. The rating of the Orders Project is affected by the Chairman's "Uncertain" reply. He indicated that he did not know enough about the project to comment.

T A B L E 60

FACTORS INFLUENCING SUCCESS AT COMPANY THETA

CONTROLLING	Rating
- Level of Top Management Support	P
- Level and Nature of Sponsorship	M
- Level of Systems Development	P
- Availability of Computer Support	P

(continued overleaf)

FACTORS INFLUENCING SUCCESS AT COMPANY THETA (continued)

ASSISTING	Rating
- Influence and Reputation of OR/MS Group	P
- Relevance and Success of Projects	P
- Formalization of Procedures	M
- Level of Client Receptivity	M
- Nature and Competence of OR/MS Personnel	P

G. RESULTS OF FIELD STUDY IN COMPANY KAPPA

Company Background

Company Kappa was formed in 1962 as a joint venture between a South African and an international organization. The company manufactures a variety of textiles using synthetic and natural fibres. The company is not quoted and does not disclose any operating information. However comments made by various members of Top Management during the field study would indicate that the company is only marginally profitable. Turnover for 1974 was approximately R28,0 million.

The Head Office and factory of Kappa is located in Johannesburg whilst there are sales offices in Durban, Cape Town, Bloemfontein and Port Elizabeth. The company employs about 500 people, the majority of whom work in the factory.

The company draws heavily on its international associate for technical expertise. Many of the Kappa employees are seconded from abroad on assignments from 1 month to 1 year duration. There is a constant interchange of information between local and international Top Management. The OR/MS activities described in this field study have all been modelled on similar applications in Britain and Europe.

History of OR/MS Activity

The OR/MS activity in Company Kappa is located in the Production Planning Department which is an integral part of the

permanent organization structure of the company. It is extremely difficult to define which are the OR/MS areas used in Production Planning as they are all closely interlinked. However the three main functions performed by the Production Planning Department are to:

(a) Forecast anticipated demand for all products.
(b) Scan Inventory Records based upon demand.
(c) Schedule Production of products with inadequate availability.

The company has been operating these three systems since it started in 1962. Initially all three functions were performed manually, but in 1969 it was decided to computerise the total operation as a result of the increasing complexity of the manufacturing operations. The computerised system was installed in stages between 1970 and 1972, by which time it was theoretically complete. At the time of the field study the system was still not operating successfully, and much of the information produced was suspect.

The Production Planning Department at Kappa consists of four analysts, all of whom have been with Kappa since the company started. The four analysts have an average of 15 years experience in the planning and control of textile production. None of the analysts have actual EDP experience although several of them worked closely with the DP Department at Kappa when the computerised systems were designed and installed.

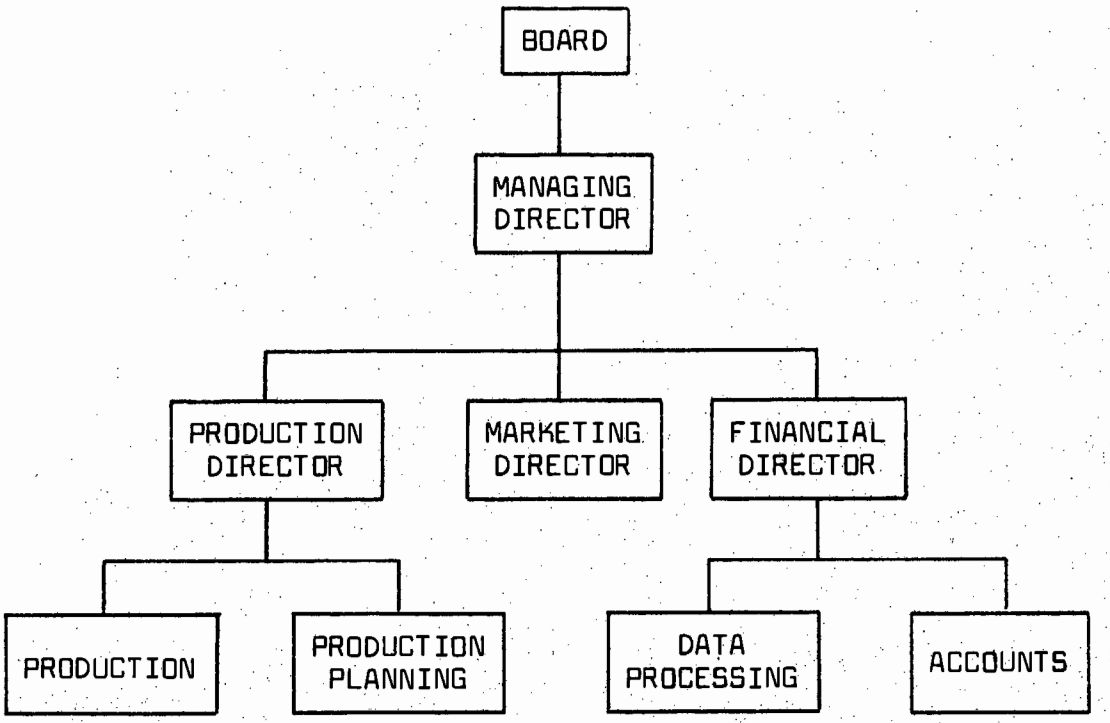
Kappa has an in-house Computer Department which produces all the accounting and financial information required within the company. The Department is staffed by a DP Manager, two systems analysts, three programmers, two operators, and three encoder operators. Individual departments are generally responsible for their own data capture. None of the DP staff have had previous experience of OR/MS situations although the majority of programmes used by the Production Planning Department are packages obtained from the international partner.

Top Management Profile

The Top Management Group at Kappa is very small, consisting of the Managing Director, and the Directors of Marketing, Planning and Finance. These four Directors work as a Management Team which reports to the Board of Directors which is made up of nominees from the two controlling companies. In view of the specialised nature of the business, the Management Team really controls the operation of Kappa. A partial organization structure showing the location of Production Planning and DP Departments is given in Figure 13.

F I G U R E 13

PARTIAL ORGANIZATION STRUCTURE OF COMPANY KAPPA



Brief biographical details are given on these four members of Top Management of Kappa below.

T A B L E 61

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT AT COMPANY KAPPA (July 1973)

Managing Director (56) B.Sc. Has been with Kappa since it started in 1962, was Works Manager at thefactory until 1968 and then Managing Director. Has over thirty years textile experience, previously being employed in the UK.

Production Director (41) B.Sc. (Chemistry). Joined Kappa from the South African partner in 1962 and became Production Director in 1970. Although he lacks a fundamental textile training is extremely knowledgeable.

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT

AT COMPANY KAPPA (continued)

Marketing Director (45) MIMM (SA). Has been with Kappa for five years, previously the Sales Manager of a competitor. Has fifteen years experience in the marketing of textiles and fibres.

Financial Director (52) CA (SA). Joined Kappa as the Chief Accountant in 1965 and was promoted to Financial Director when the previous Director returned to Britain.

disclosure?

ANALYSIS OF COMPANY KAPPA

OR/MS Life Cycle

The OR/MS Group is formally integrated into the organization structure of Kappa as the Production Planning Department. The Group started in 1962 when the company was formed and has become progressively more influential in the intervening time. The activities of the Group are modelled on the activities of a similar group in the international parent. The Production Planning Department is in the Maturity Phase of the Life Cycle of OR/MS activity. The Department did not go through the first three phases of the Life Cycle as its existence was specified in the initial organization structure of Kappa.

Primary and Secondary Processes

Top Management at Kappa did not go through the Primary Process of OR/MS diffusion as the OR/MS activity was incorporated in the organization structure of the company from the outset. The Secondary Process is not yet complete, as neither Top Management nor the lower levels of Management in Kappa have adopted the

OR/MS techniques used by the Production Planning Department. They are however unable to reject the techniques as their use is required by the international parent.

Sponsorship

The international parent of Kappa can be readily identified as the sponsor of the OR/MS activities performed in the company. The sponsorship is Authoritative rather than Participative.

PRIMARY PROCESS AT COMPANY KAPPA

Receptivity of Top Management

The Top Management of Company Kappa is an excellent example of a highly Receptive group where Receptivity is dictated by the policies of the sponsor, the required organization structure and reporting systems of the organization. This is shown clearly in Table 62.

T A B L E 62

RECEPTIVITY OF TOP MANAGEMENT OF COMPANY KAPPA TOWARDS OR/MS

Top Manager	% Receptivity
Managing Director	E
Financial Director	S
Production Director	E
Marketing Director	S

The factors controlling Receptivity exert a significant effect but the influence of Assisting factors is not as marked.

T A B L E 63

FACTORS AFFECTING RECEPTIVITY AT COMPANY KAPPA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	P
- Professionally Trained Top Management	P
- Availability of EDP Expertise	M
ASSISTING	
- Top Management Exposure to Innovation	M
- Influence of Management Graduates	M
- Influence of International Consultants	N
- Use of OR/MS by Competition	N
- Increased Competition, Reduced Profits	M
- Increased Size of Operation	M
- Government Involvement	N

Company Kappa is interesting as it possesses an extremely well designed Information System which is modelled entirely upon that of the international company.

T A B L E 64

INFORMATION SYSTEMS RATING IN COMPANY KAPPA

LOCIS	System ISR	= 0,85
PAOCIS	System ISR	= 0,75
FOCIS	System ISR	= 0,93
MOCIS	System ISR	= 0,71
OVERALL ISR		= 0,86

SECONDARY PROCESS AT COMPANY KAPPA

The Production Planning Group is carrying out three separate projects although they do appear to be integrated - Demand Forecasting, Inventory Control, Production Planning. Production Planning generally would not be recognised as an OR/MS technique, however the fairly sophisticated computerized planning model meets the requirements of the OR/MS definition. The Success ratings of Top Management are given below.

TABLE 65

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT KAPPA

Manager	Forecasting	Inventory	Planning
Managing Director	S	N	N
Financial Director	M	U	U
Marketing Director	S+	F	S
Production Director	S	F	S

The very different perceptions of Success can be explained in terms of the individual's knowledge of the faults in the three systems. Due to errors in data input the Inventory System is producing erroneous information for the Production Planning System. The Marketing Director and Production Director are aware that the planning system is working well. However both the Managing Director and Financial Director feel that both systems are at fault.

Table 66 displays the rating of factors believed to influence Success.

TABLE 66

FACTORS AFFECTING OR/MS SUCCESS AT COMPANY KAPPA

	Rating
CONTROLLING	
- Level of Top Management Support	P
- Level and Nature of Sponsorship	N
- Level of Systems Development	P
- Availability of Computer Support	M
ASSISTING	
- Influence and Reputation of OR/MS Group	M
- Relevance and Success of Projects	P
- Formalization of Procedures	M
- Level of Client Receptivity	N
- Nature and Competence of OR/MS Personnel	M

the Merchandising Information System.

It is not difficult to explain the low Receptivity Ratings of Delta Top Management. Table 43 lists the scoring for the factors believed to influence Receptivity and these confirm that Delta is an unfortunate environment in which to establish OR/MS. The Information Systems Ratings shown in Table 44 also highlight the inadequate systems development in Delta.

TABLE 43

FACTORS AFFECTING RECEPTIVITY IN COMPANY DELTA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	N
- Professionally Trained Top Management	N
- Availability of EDP Expertise	N
ASSISTING	
- Top Management exposure to Innovation	N
- Influence of Management Graduates	N
- Influence of International Consultants	N
- Use of OR/MS by Competition	N
- Increased Competition, Reduced Profits	P
- Increased Size of Operations	N
- Government Involvement	N

TABLE 44

INFORMATION SYSTEMS RATING IN COMPANY DELTA

LOCIS System	= 0,35
PAOCIS System	= 0,13
FOCIS System	= 0,33
MOCIS System	= 0,28
OVERALL ISR	= 0,29

? LAMBDA beginnings ?

Although Lambda stocks and has stocked leading makes of Continental and British cars, there does not seem to have been any concerted effort to acquire overseas expertise and systems.

History of OR/MS Activity

The only identifiable OR/MS activity at Lambda is in the area of parts acquisition and control. This is an extremely important area of the business of the company as investment in spares has risen from R1,0 million in 1960 to R4,2 million in 1973. The line item count has increased from 32 000 to 73 000 over the same period. Stockturn of spares has dropped from 2,1 per annum to 0,9 per annum as sales of spares have not increased as fast as investment in stock.

The company has always maintained a Spare Parts Control Group which had been responsible for the ordering and control of parts. The task of this group became progressively more complex as Lambda dealerships changed and as the parts catalogue grew. Until 1968 parts records and orders were controlled on a Kardex System maintained in Johannesburg. This was an extremely simple system and it was evident to the Workshop Manager that it was no longer suitable for the large number of line items and the increased number of branches. In addition the lag in the processing of clerical work resulted in records being as much as three weeks out of date.

Lambda suffered an operating loss of R120 000 in 1968, the worst year in its history. A portion of this loss could be

attributed to poor spare parts availability and control. The Workshop Manager of Lambda recruited an experienced Parts Controller from Germany who started working in Lambda in February 1969. The Parts Controller had over twenty years experience in automobile spares control, and during the last six years had been responsible for the design and implementation of a computerized stock control system for a leading West German Mercedes Benz dealer.

The Controller signed a contract with a Johannesburg computer bureau for the use of their Scientific Inventory Management Package. He recruited an additional stock controller from one of the motor assemblers in Pretoria and spent several months training the existing staff in the spare parts control group. Table 68 presents figures for five stock criteria between 1969 and 1973.

T A B L E 68

INVENTORY MANAGEMENT RECORDS FOR COMPANY LAMBDA

	1969	1971	1973
Branches	4	5	7
Line Items	41 000	58 000	73 000
Stockturn	0,6	1,1	0,9
Investment	R2,8 million	R3,7 million	R4,2 million
Service	76%	84%	75%

As the table shows service and stockturn did improve between 1969 and 1971. However the number of the items and the investment in parts also increased significantly. This was due

to the increased number of branches and the changes in dealership. Between 1971 and 1973 service and stockturn dropped as line item count and investment in stock increased.

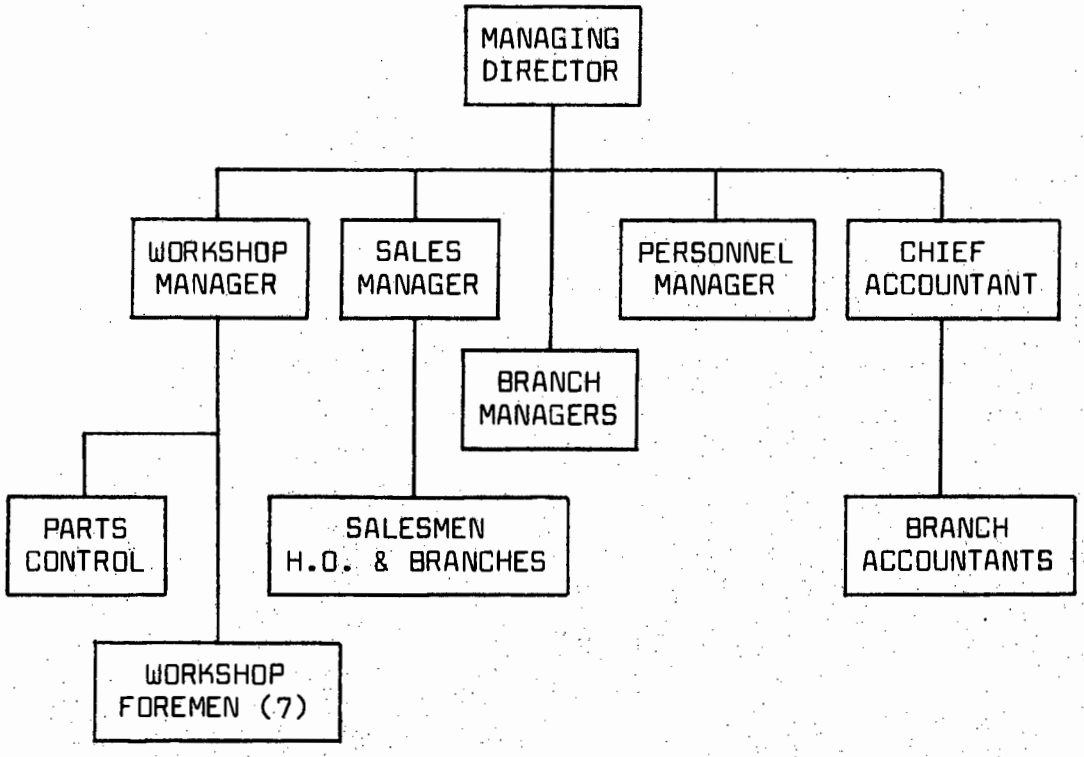
Research in Company Lambda at the time of the field study showed that the Inventory Control System was fundamentally sound and well designed. Ineffective branch management, poor clerical training, weak supervision and lags in paper work flow made the output from the computerized control system meaningless.

Top Management Profile

The Top Management team at Lambda includes two brothers and a cousin whose parents founded the company. Although there are two further individuals who function as part of the Top Management team, they take little part in the decision-making process of the organization. Figure 14 shows the organization structure and Table 69 gives brief biographical details of the five Top Managers.

F I G U R E 14

PARTIAL ORGANIZATION STRUCTURE AT COMPANY LAMBDA



T A B L E 69

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT AT COMPANY LAMBDA

Managing Director (57) The son of the founder of Lambda. Has worked in Lambda since leaving school, served his time as an apprentice and has worked in Sales. Functions as Marketing Manager arranging promotions, special offers etc.

Workshop Manager (52) Born and trained in Britain. Immigrated to South Africa after World War II, worked in various motor firms before joining Lambda in 1965. Has been largely responsible for the reorganization of Lambda workshops and improvements on the floor.

SUMMARY BUIGRAPHICAL DETAILS OF TOP MANAGEMENT

AT COMPANY LAMBDA (continued)

Sales Manager (45) Managing Director's brother who joined Lambda in 1965 after a variety of jobs. Has a reputation for being an effective salesman.

Personnel Manager (58) Joined Lambda in 1960 from the Transvaal Goldmines where he was a Personnel Officer.

Chief Accountant (45) CA (SA) Cousin of Managing Director. Has held this position since 1953 when he joined Lambda after serving articles.

ANALYSIS OF COMPANY LAMBDA

OR/MS Life Cycle

The Spares Control Group has always existed in Company Lambda. Originally one or two individuals maintained Kardex records of movement of all line items and reordered parts based upon personal observation of historical trends. By 1965 the Group had expanded to five - a controller and four clerks - in order to handle the increased number of line items, dealerships and branches. The Group did not employ statistical demand forecasting techniques, nor recognised reorder models.

In 1966 the new Workshop Manager found that off-the-shelf service had dropped below 70%, although parts inventories had continued to increase. Between 1967 and 1969 he tried to improve the availability of spares in Johannesburg and the branches but found that he did not have the necessary skills to handle the complex situation that had developed.

The Prebirth Phase of the Life Cycle at Company Lambda ended with the arrival of the new Parts Controller in February 1969. The Introductory Phase was marked by a general agreement on the part of Top Management to allow the Parts Control Group to introduce a more sophisticated forecasting and reordering model. However no further management support was forthcoming and by the time of the field study (June/October 1973) the Group was still in the Introductory Phase. The necessary paperwork systems to support the upgraded stock control model were only partially implemented at branch level.

Primary and Secondary Processes

The Primary Diffusion Process of OR/MS at Lambda was complete when the Top Management of the company agreed to the employment of a new Parts Controller in early 1969 and the subsequent implementation of the modified control system. The Secondary Process was definitely not complete by October 1973 as the new system had not been accepted by managers at Branch level nor had it been completely rejected by Top Management. There were definite indications that Top Management had begun to believe that the expenditure on the improved system had not been justified.

Sponsorship

The Workshop Manager of Lambda can be clearly identified as the sponsor of OR/MS activity in the company. Although he succeeded in enlarging the Group and introducing a computerized system, he was unable to get commitment and support from other members of Top Management. This was partially due to his

reputation which was based entirely on his ability as a workshop foreman. Subordinates in other departments tended to resent his involvement in the inventory project and found that their superiors were not particularly concerned.

PRIMARY PROCESS AT COMPANY LAMBDA

Receptivity of Top Management

The decision-making in Company Lambda is confined mainly to the three family members. The Receptivity ratings immediately highlight the fact that these individuals were extremely sceptical about the Inventory project even though they had agreed to it initially.

TABLE 70

RECEPTIVITY OF TOP MANAGEMENT AT COMPANY LAMBDA TOWARDS OR/MS

Top Manager	% Receptivity
Managing Director	H
Chief Accountant	I
Sales Manager	H
Personnel Manager	H
Workshop Manager	S (ερωτων)

Although the Workshop Manager was extremely enthusiastic about the Inventory project his general ability and knowledge of systems and OR/MS was not adequate to enable him to overcome the disinterest of his colleagues.

Tables 71 and 72 show the Rating of Factors influencing Receptivity and the Information Systems Rating.

T A B L E 71

FACTORS AFFECTING RECEPTIVITY AT COMPANY LAMBDA

	Rating
CONTROLLING	
- Influence of International Parent	N
- Professionally Trained Top Management	N
- Availability of EDP Expertise	N
ASSISTING	
- Top Management Exposure to Innovation	M
- Influence of Management Graduates	N
- Influence of International Consultants	N
- Use of OR/MS by Competition	M
- Increased Competition, Reduced Profits	P
- Increased Size of Operation	P
- Government Involvement	N

T A B L E 72

INFORMATION SYSTEMS RATING IN COMPANY LAMBDA

LOCIS	System ISR	= 0,35
PAOCIS	System ISR	= 0,26
FOCIS	System ISR	= 0,33
MOCIS	System ISR	= 0,14
OVERALL	ISR	= 0,30

SECONDARY PROCESS AT COMPANY LAMBDA

OR/MS activity at Lambda is still in the Introductory Phase of the Life Cycle, as Top Management have not as yet decided to formally adopt or reject the systems which the Spare Parts Control Group have been trying to introduce for five years. One of the main reasons for this is that the Trial Phase of the Top Management Diffusion process is not yet complete because the entire inventory project is involved. It is possible that Top Management of Lambda might have been more supportive of a smaller project which tackled only one of the problem areas of stock control. Rapid success with easily visible results may have made Top Management more aware of the implications of the Total Inventory Project. Table 73 indicates that the project has not been favourably received by Top Management.

T A B L E 73

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT LAMBDA

Manager	Inventory Project
Managing Director	F
Sales Manager	U
Chief Accountant	F
Personnel Manager	U
Workshop Manager	M

Neither the Managing Director nor the Chief Accountant felt that the investment in the Spares Control Group had been justified, and the Chief Accountant felt that the exercise had been a waste of money.

On the basis of the hypothesis of factors influencing Success, Table 74 shows very clearly that the changes of OR/MS success at Company Lambda are slight.

T A B L E 74

FACTORS AFFECTING OR/MS SUCCESS AT COMPANY LAMBDA

	Rating
CONTROLLING	
- Level of Top Management Support	N
- Level and Nature of Sponsorship	M
- Level of Systems Development	N
- Availability of Computer Support	N
ASSISTING	
- Influence and Reputation of OR/MS Group	N
- Relevance and Success of Projects	N
- Formalization of Procedures	N
- Level of Client Receptivity	N
- Nature and Competence of OR/MS Personnel	M

I. RESULTS OF FIELD STUDY IN COMPANY SIGMA

Company Background

Company Sigma is one of the larger firms of building contractors in South Africa. The company has been established for over forty years and is recognised as a progressive and efficient organization by its competitors. The company is quoted and has shown satisfactory growth in profit during the last five years.

TABLE 75

PROFIT PERFORMANCE FOR COMPANY SIGMA*

Year ending Dec. 31st	1969	1970	1971	1972	1973	1974
Profit Before Tax (R000)	3 750	6 235	9 675	9 500	11 275	13 375

*Source: Company Records

Turnover of Company Sigma is not known but was believed to be in excess of R50 000 million in 1974.

The company has its Head Office in Johannesburg and branches in Durban, Cape Town, Port Elizabeth and Bloemfontein. The branches in smaller towns are often run by contractors who operate as agencies for Sigma.

The company has no international partners but maintains close links with a number of American and British civil engineering consultants and construction companies. Sigma has found this an

CPM/PERT seems to be the most noteworthy application

invaluable source of information regarding technical developments in civil engineering practice. In addition to technical information these contacts have also provided the Top Management of Sigma with opportunities to study the application of a great many OR/MS techniques used by international consulting firms.

History of OR/MS Activity

Company Sigma started using OR/MS techniques in 1965 when the company first applied CPM/PERT to control a major civil engineering project with a large number of sub-contractors. This project was supervised and controlled by a Head Office Planning Group which had been set up in 1960 for the overall control of projects. The majority of the Top Management of Sigma had been aware of the potential of CPM/PERT for several years but had not felt that it was necessary to employ the technique because of the size of projects handled by the company. The 1965 project was sufficiently complex to warrant the introduction of CPM/PERT.

The project was completed in 1967. At this point in time most members of the organization agreed that CPM/PERT was a more effective form of control than anything else that had been used previously. The company was fortunate enough to employ the services of a local computer bureau which had handled CPM/PERT networks for several other industrial users in Durban. One of the bureau partners had spent several years in Britain running Planning projects and was familiar with the various facets of the technique.

In 1967 the Top Management of Sigma made the decision to use CPM/PERT on all complex or large projects particularly those involving a great number of subcontractors. At this point in time the Planning Department consisted of two civil engineers and one quantity surveyor who were assisted by four clerks. All three professional members of the Department had several years of construction experience and the leader - one of the civil engineers - spent six months in London with a firm of civil engineering consultants studying CPM/PERT.

In 1969 the company introduced Resource and Responsibility Allocation versions of CPM/PERT because it was felt that this would provide the Planning Department with further details to assist in the control of major projects. The Planning Department subsequently found that it did not have enough personnel to prepare the programmes and supervise the networks once the projects were underway. In 1971 the Department strength was increased when two site foremen, also civil engineers, were seconded to the Group to assist in the supervision of the methods. It was hoped to second all site foremen to the Department over a period of time to make them more familiar with CPM/PERT.

In 1972 the Department started to work on the computerization of Bills of Quantities for tenders. The Planning Manager believed that it should be possible to programme and supervise a major project from the tender stage to completion, and produce reports on variations from budget at various stages of the job. The first stage in the total programme was the computerization of

the Bills of Quantities. All stages of computerization were to be implemented by the computer bureau which had initially been involved in the CPM/PERT project.

Top Management Profile

With the exception of the Financial Director, the Top Management Team of Sigma was made up entirely of Civil Engineers. All policy decisions in Sigma were made by an Operating Board which consisted of the five members of Top Management. This group was characterized by a greater feeling of co-operation and commitment than was encountered in any of the other nine field studies. The organization structure of Sigma is shown in Figure 15.

F I G U R E 15

PARTIAL ORGANIZATION STRUCTURE OF COMPANY SIGMA (January 1974)

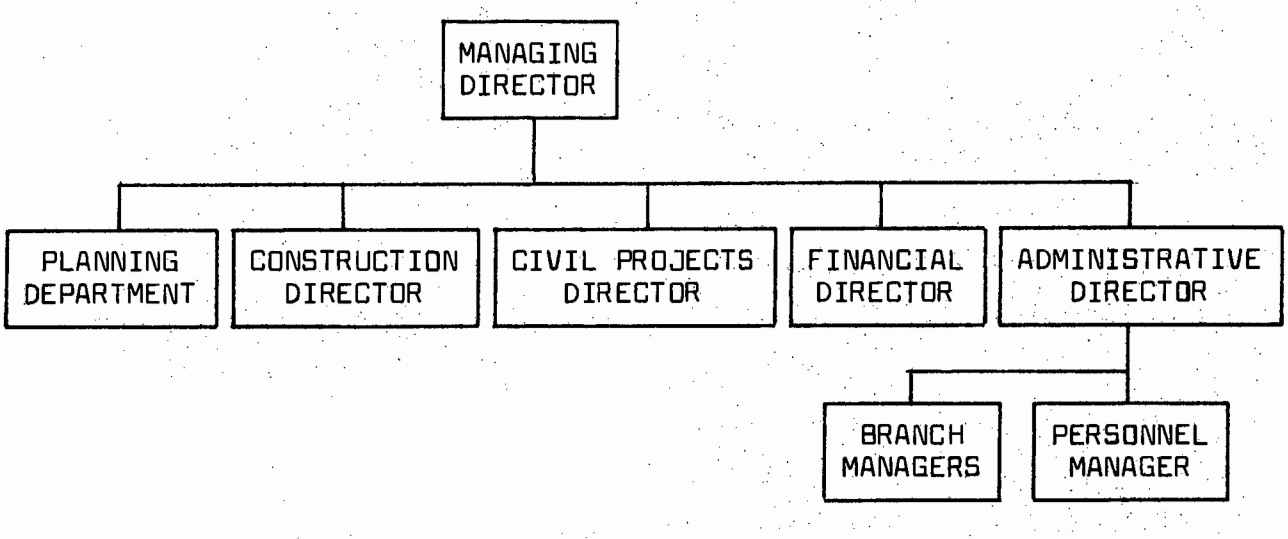


Table 76 gives biographical details of the six managers.

T A B L E 76

SUMMARY BIOGRAPHICAL DETAILS OF THE TOP MANAGEMENT AT COMPANY SIGMA (January 1974)

Managing Director (52) B.Sc. (Civil & Mech). Joined Sigma as a site foreman and became Director of Construction Division in 1965. Appointed Managing Director in 1969.

Construction Director (47) B.Sc. (Civil). Qualified as a civil engineer in America in 1950 and worked in America until 1960. Joined Sigma in 1964 and made a Director in 1969.

Civil Projects Director (55) B.Sc. (Civil). Joined Sigma after World War II and went back to university in 1957. Worked as Cape Town Branch Manager until 1967 and then made Civil Projects Director.

Financial Director (40) CA (SA), CWA. Five years with Sigma. Previously employed by a large engineering company where he had been responsible for the introduction of standard costing systems.

Administrative Director (42) B.Comm., B.Sc. (Civil). Completed his B.Comm. by correspondence whilst working as a civil engineer in the field for Sigma. With Sigma for fifteen years. Responsible for the co-ordination of activities of branches.

Planning Dept ?

ANALYSIS OF COMPANY SIGMA

OR/MS Life Cycle

OR/MS activity is formally integrated into the organization structure of Sigma in the form of the Planning Department. OR/MS started as an Externally Induced process in 1965 when CPM/PERT was used to co-ordinate a major project. The Introductory Phase of the Life Cycle extended to 1967 when the project was successfully completed and CPM/PERT scheduling was adjudged to be a success.

Banks + Oil Companies

The OR/MS activity moved from the Introductory to the Maturity Phase of the Life Cycle when the Top Management of Sigma decided to apply CPM/PERT control to all major or complex construction projects.

In addition to the control of the scheduling of major construction projects using CPM/PERT, two further OR/MS activities are being used at Company Sigma. The first involves the use of a more powerful version of CPM/PERT - PERTRAP which control the Allocation of Resources and the assigning of responsibilities. The Planning Group was expanded as a result of the increased work-load arising from the implementation of PERTRAP programmes.

The second OR/MS activity, which is currently being developed, is the computerization of Bills of Quantities. Although this is the third project handled by the Planning Group it will provide the preliminary data base in the Planning and Control of Construction projects.

At the time of the field study, neither the PERTRAP nor the Bills of Quantities applications had been developed adequately to be included in normal operating procedures to control major construction and roadmaking projects.

Primary and Secondary Processes

The Primary Diffusion Process of OR/MS at Company Sigma was complete in 1965 when the Top Management of the company decided to run a trial on CPM/PERT. The Trial phase of the Authority-

Innovation Decision process was complete in 1967 and the Secondary Diffusion process was definitely complete by 1969 when CPM/PERT had been adopted at all levels within Sigma.

Sponsorship

There does not seem to be any single individual who has been actively involved in the sponsorship of OR/MS activities. The Planning Department can be identified as the departmental promoter or sponsor of OR/MS as it has been instrumental in getting Top Management to formally incorporate CPM/PERT in the control systems of the company. The Department has used OR/MS to increase its own standing within the company, and as a result the department has increased in size and has become a far more powerful function than it was previously.

Does it belong to Top Mgt or not?

PRIMARY PROCESS AT COMPANY SIGMA

Receptivity of Top Management

The Top Management of Sigma were responsible for the introduction of CPM/PERT into the Planning Department of the company. Discussions with the members of the Management Team revealed that they were generally in favour of innovation, provided that it could be shown to be in the best interests of the company.

The Receptivity Ratings of the five members of Top Management are given in Table 77.

T A B L E 77

RECEPTIVITY OF TOP MANAGEMENT OF COMPANY SIGMA

TOWARDS OR/MS

Top Manager	Receptivity
Managing Director	S
Financial Director	S
Administration Director	S
Construction Director	S
Civil Projects Director	S

The uniformly favourable Receptivity Rating of Top Management is confined by the presence of the Controlling factors influencing Receptivity (Table 78). However Table 79 shows that the level of systems development in the company is low.

T A B L E 78

FACTORS AFFECTING RECEPTIVITY AT COMPANY SIGMA

	Rating
CONTROLLING	
- Influence of International Parent/Associate	M
- Professionally Trained Top Management	M
- Availability of EDP Expertise	M
ASSISTING	
- Top Management Exposure to Innovation	M
- Influence of Management Graduates	M
- Influence of International Consultants	M
- Use of OR/MS by Competition	M
- Increased Competition, Reduced Profits	M
- Increased Size of Operations	M
- Government Involvement	M

T A B L E 79

INFORMATION SYSTEMS RATING AT COMPANY SIGMA

LOCIS	System ISR	=	0,43
PAOCIS	System ISR	=	0,25
FOCIS	System ISR	=	0,60
MOCIS	System ISR	=	0,43
OVERALL ISR		=	0,45

SECONDARY PROCESS AT COMPANY SIGMA

OR/MS has reached the Maturity Stage of the Life Cycle in Company Sigma. CPM/PERT networks form a required part of the planning techniques employed by the company, and have been adopted at all levels within the organization. Theoretically the Secondary Process of OR/MS diffusion is also complete. The success of the Trial Phase (1965-1967) justified the adoption of OR/MS by Top Management and the decision to introduce CPM/PERT was taken in 1967. Subsequent CPM/PERT projects have been equally successful and the field study showed that by 1974 the majority of subordinates within the organization had also adopted the technique.

However it is also apparent that both the Top Management of Sigma, and subordinates within the organization, regard the PERTRAP and Bill of Quantity projects with a great deal of scepticism. Neither of the projects have been formally adopted by Top Management although the PERTRAP exercise started in 1969 the the Bill of Quantity exercise in 1972.

Top Management of Sigma believe that the supervision and control of these two projects cost the company more than the savings achieved by improved management. There are too many exceptions and complications in both to permit them to be introduced into the day-to-day operating systems. The writer feels that the fundamental systems required to support the PERTRAP and Bill of Quantity projects are not sufficiently well defined to provide the necessary input.

The perceived success of the CPM/PERT project is partially due to the fact that the CPM/PERT networks are used for planning in Sigma and not control. As a result the feedback information systems required for control are not required and not developed. Table 80 clearly shows the different attitudes of Top Management towards the three OR/MS projects.

T A B L E 80

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS

AT COMPANY SIGMA

Manager	CPM/PERT	PERT/RAP	Bill of Q.
Managing Director	S+	F	N
Financial Director	S	N	N
Construction Director	S+	F	N
Civil Proj. Director	S+	F	F
Admin. Director	S	N	N

Although the Bill of Quantities project is not totally rejected by Top Management, the PERT/RAP project is considered a

failure by the two Directors most intimated involved with it. This may lead to its ultimate rejection.

Table 81 shows the rating of factors influencing OR/MS success at Company Sigma.

T A B L E 81

FACTORS INFLUENCING OR/MS SUCCESS AT COMPANY SIGMA

	Rating
CONTROLLING	
- Level of Top Management Support	M
- Level and Nature of Sponsorship	M
- Level of Systems Development	M
- Availability of Computer Support	M
ASSISTING	
- Influence and Reputation of OR/MS Group	M
- Relevance and Success of Projects	P
- Formalization of Procedures	N
- Level of Client Receptivity	M
- Nature and Competence of OR/MS Personnel	M

J. RESULTS OF FIELD STUDY IN COMPANY OMEGA

Company Background

Company Omega was founded in the late 1950's and until 1965 consisted of three medium-sized supermarkets. In May 1965 the company was purchased from its original owners. The new owners believed that the strength of a supermarket chain lay in the buying power of the chain, and actively pursued a policy of acquisition. By 1970 Omega had forty-one outlets, and at the time of the field study - July 1972 - the number had increased to forty-eight with two additional branches under negotiation. Acquisitions included two separate chains, with ten and seventeen branches respectively, and several privately owned supermarkets in convenient locations.

Omega operated primarily as a supermarket handling normal lines of consumerables. However at the time of the field study, Top Management were giving thought to the introduction of selected lines of children's and ladies wear. The company was privately owned and operating information was not released by management. Omega was believed to have achieved profits in excess of R50 000 for the 1973 financial year, after reporting losses for five previous years.

Head Office of Omega was in Durban with branches throughout Natal and several in the North Eastern Cape. Apart from Durban, the main concentration of outlets varied significantly, ranging from two extremely large branches in Virginia and Pinetown

(which were as large as any other supermarket branch in South Africa) to six or seven "Momma and Poppa" stores in the smaller coastal resorts. Omega branches retained their original trading names and as a result the company did not have an identity with the general public.

Although the owners of Omega travelled abroad regularly, this was primarily on behalf of the other business activities in which they were involved. There was very little feedback to Omega on international trends in supermarketing, discounting etc. The remainder of Omega Top Management were not encouraged to travel extensively.

History of OR/MS Activity

In March 1968 the Top Management of Omega decided to alter company policy with regard to Buying. Until 1968 Branch Managers had been permitted to do their own buying for their stores, with the exception of certain lines for which Group discounts had been negotiated. These were ordered through Head Office. However it was necessary to reverse this policy to take advantage of quantity discounts across all lines and in addition to reduce the number of creditors. This was particularly important as Omega had begun centralizing accounts control in Durban in January 1967. At that time the company had over 5 000 creditors' accounts which Top Management believed was excessively high.

In order to process the paperwork involved in the centralized accounts project, all documents were batched and dispatched to Durban from the branches each day. The processing was handled by a large bureau in Durban which was already doing wages, salaries, and debtors for Omega. By the end of 1967 the centralization project was technically complete but had run into significant problems as a result of the enormous volume of creditors' invoices coming in from the branches. This had forced Top Management of Omega to accelerate the introduction of centralized buying which had been bitterly resisted by the majority of branch managers.

Although the centralization of accounts was the responsibility of the Financial Director, the Merchandising Director was made responsible for the centralizing of buying. Three subsystems were required to support the centralized buying project and these necessitated the enlarging of the Head Office Buying Department. The most important subsystem was the Stock Movement Report which detailed movement of all lines at all branches for the previous week. Buyers used this Report to establish trends, plan promotions and set prices on special offers. The second subsystem was the Order Generation Report which produced proforma orders on major suppliers using theoretical reorder points and stocks. The two subsystems supported the third subsystem - Goods Received - which was reconciled with creditors' invoices prior to payment.

The design of the three systems was performed by the Merchandising Director of Omega and two of the more experienced Buyers. Programmes for the systems were written by the bureau and were complete by November 1968. Trial runs on the systems were carried out in two branches of Omega during January to March 1969 and after minor modifications were accepted by the Buyers and Top Management of Omega. The systems were introduced into Omega on a store-by-store basis from July 1969 onwards.

At the time of the field study, July 1972, the centralized buying system was installed in all branches and was theoretically successful. Although the company had added a further twenty branches, the number of monthly creditors processed was less than 2 000. In addition Omega had negotiated large discounts with major suppliers and had succeeded in establishing a common merchandising identity in the branches.

Discussions with branch managers and merchandisers indicated that major problems still existed. Theoretical and physical stock counts at branches did not agree. Stockturn at branches had decreased significantly and the company average stockturn had dropped from an average of 12 per annum to 8,3 per annum between 1969 and 1972. Buyers complained that branch managers did not devote enough time to merchandising. On the other hand branch managers reported that they were often out of stock of fast moving items, and were sometimes supplied with merchandise they did not want. Finally the branch managers complained that they spent a great deal of time checking and

correcting incorrect coding on delivery notes.

The Financial Director and the Bureau Manager reported that incorrect coding at branches resulted in a great deal of unnecessary punching, verification, and rerunning. Unmatched creditors' invoices continued to be the most serious data processing problem.

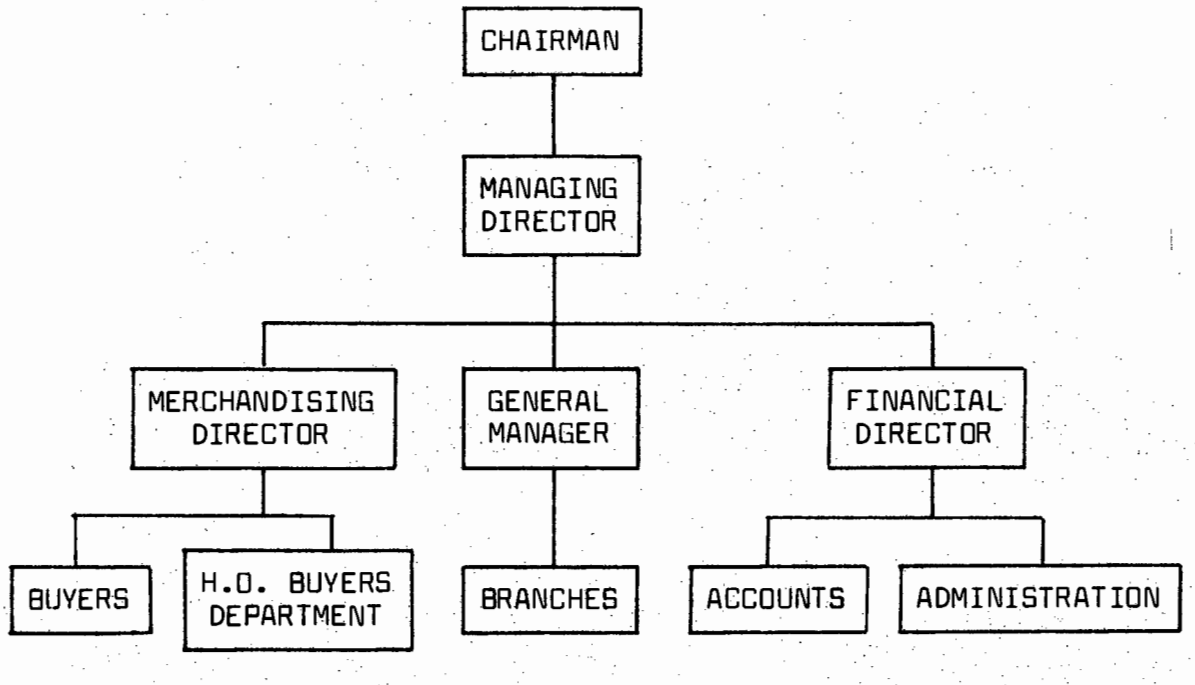
Top Management Profile

With the exception of the two relatives who had purchased Omega in 1965, all other members of the Top Management Team had been owners or managers of the various supermarkets acquired by Omega during the period 1965 to 1972. Many of the original owners had left when Omega bought them out but several had remained. In particular executives from the two chains which had been purchased tended to occupy senior positions in the company.

Figure 16 depicts the important features of the organization chart and brief biographical details of the members of Top Management are given in Table 82.

F I G U R E 16

PARTIAL ORGANIZATION STRUCTURE OF COMPANY OMEGA



T A B L E 82

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT

AT COMPANY OMEGA (30.7.1972)

Chairman (58) B.Comm., CIS. A majority shareholder of Omega, together with Managing Director. Entrepreneur and chairman of several other companies in unrelated fields. No previous supermarket experience.

Managing Director (56) B.Sc. Chairman's cousin and joint owner of Omega. Has successfully built up several companies in the past including a pharmacy chain. Twenty years retailing experience.

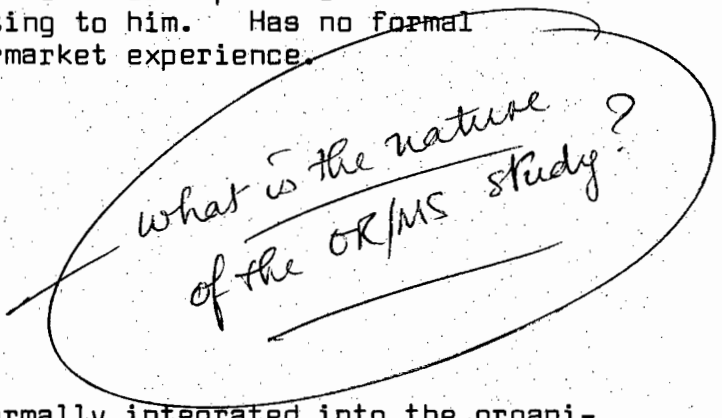
Merchandising Director (48). Originally owner of smaller (10 branches) supermarket chain purchased by Omega, which he had built up over ten years. Was forced to sell due to financial difficulties. Fifteen years experience in retailing, discounting and supermarkets.

SUMMARY BIOGRAPHICAL DETAILS OF TOP MANAGEMENT

AT COMPANY OMEGA (continued)

Financial Director (42) B.Comm., CA. Previously Financial Controller of larger chain bought by Omega. Has over fifteen years experience in design and implementation of accounting systems.

General Manager (48). Has worked at Omega since 1958 and was a branch manager when the company was purchased by present owners in 1956. Became General Manager of store operations in 1968 and has six regional managers reporting to him. Has no formal education but considerable supermarket experience.



ANALYSIS OF COMPANY OMEGA

OR/MS Life Cycle

The OR/MS group is formally integrated into the organization structure as part of the Head Office Buying Department. The Group was created as the result of an Externally Induced Process in March 1968 and the Introductory Phase of the Life Cycle continued until March 1969. At this point in time Top Management accepted the centralized Buying systems on the basis of a Trial conducted in two branches of Omega.

During the next three years OR/MS activities moved through the Transitional Phase into the Maturity Phase as more and more branches became involved in Centralized Buying. At the time of the field study the Top Management of Omega had accepted the group as a permanent part of the organization structure.

Primary and Secondary Processes

The Primary Process in Omega was complete in March 1968 when Top Management decided to run a Trial of a computerized Centralized Buying system. The Secondary Process was not complete at the time of the Field Study as the Buying system had not been adopted by subordinates within the organization.

Sponsorship

The Merchandising Director was appointed sponsor of the Centralized Buying project by Top Management. The choice was inevitable as the Buying Department had to be involved in the project at all stages. The Merchandising Director possessed the majority of the necessary attributes required for successful sponsorship, however subsequent events proved that he was unaware of the systems implications at store level. The non-involvement of the General Manager and his Regional Managers during the design and Trial stages of the project was largely responsible for the resistance of Branch Managers.

Although the project had been operational for more than three years it was clear that the Merchandising Department had adopted an extremely Authoritative approach to sponsorship from the start. Regional managers were told "this is the way the system will be installed" and were subsequently made responsible for the training and implementation at branch level.

PRIMARY PROCESS AT COMPANY OMEGA

Receptivity of Top Management

Centralized Buying had been introduced as a formal organizational requirement in Omega for more than three years. However it appeared that very few members of the organization completely understood the nature and purpose of the systems which had been installed by the Merchandising Director. Nevertheless the majority of members of Top Management at Omega were extremely enthusiastic about any innovation which could improve the operation of the company. The Receptivity Ratings for OR/MS amongst Omega Top Management are given in Table 83.

T A B L E 83

RECEPTIVITY OF TOP MANAGEMENT OF COMPANY OMEGA TOWARDS OR/MS

Top Manager	Receptivity Rating
Chairman	S
Managing Director	S
Merchandising Director	E (Sponsor)
Financial Director	E
General Manager	I

The ratings highlight the fundamental problem facing Omega at the time of the field study. Although all the Directors of the company wished to introduce as many systems and control improvements as possible, the General Manager was not convinced that these changes were important. This attitude was reflected at Regional Manager and Branch Manager level. Branch Managers

in particular were openly hostile towards the concept of centralized control.

The relatively high Receptivity of Top Management at Omega is not justified by the factors which are believed to influence Receptivity (Table 84). Conceivably the problems that the OR/MS activities have encountered have been due to the significant difference in attitude that exists between Top Management and the company as a whole.

TABLE 84

FACTORS AFFECTING RECEPTIVITY AT COMPANY OMEGA

	Rating
CONTROLLING	
- Influence of International Parent	N
- Professionally Trained Top Management	M
- Availability of EDP Expertise	M
ASSISTING	
- Top Management Exposure to Innovation	M
- Influence of Management Graduates	N
- Influence of International Consultants	N
- Use of OR/MS by Competition	M
- Increased Competition, Reduced Profits	M
- Increased Size of Operation	N
- Government Involvement	N

Between 1967 and 1972 the information systems of Omega were significantly improved and modified by the Financial Director. The majority of systems were computerized and fully operational at the time of the field study. Table 85 gives the Information Systems Ratings for the four systems.

T A B L E 85

INFORMATION SYSTEMS RATINGS IN COMPANY OMEGA

LOCIS	System ISR	= 0,71
PAOCIS	System ISR	= 0,50
FOCIS	System ISR	= 0,80
MOCIS	System ISR	= 0,71
OVERALL ISR		= 0,70

The ISR's do not show that a great deal of information in the LOCIS subsystems was suspect at the time of the Field Study and this influenced the FOCIS system as well.

SECONDARY PROCESS AT COMPANY OMEGA

Although OR/MS activity at Company Omega had reached the Maturity Phase of the Life Cycle, the Secondary Diffusion Process is not yet complete. This is mainly because none of the three subsystems of the Centralized Buying project are really working effectively. The Field Study highlighted two basic difficulties that would have to be resolved before the systems were likely to work. The most serious problem arose from excessive clerical errors in the documentation submitted from the branches. This was partially due to inadequate clerical training at branch level but was also a direct result of the second problem - the fundamental rejection of the concept of centralized buying at branch level. This rejection stemmed mainly from the manner in which the project was introduced by the Merchandising Director.

Discussions with Top Management of Omega showed that they were well aware that the three phases of the Centralized Buying project had not been a success. This is shown in Table 86.

Nature of OR/MS methodology?

TABLE 86

TOP MANAGEMENT RATINGS OF OR/MS SUCCESS AT OMEGA

Manager	Stock Movement	Order Generation	Goods Received
Chairman	M	N	M
Managing Director	M	M	M
Merchandising Director	N	M	S
Financial Director	F	N	M
General Manager	F	N	M

The Stock Movement system which is used by Buyers to examine trends at branch level is the most important control of the three systems. The information in the report forms the Data Base for the Order Generation Report and is most susceptible to clerical error. As the table shows the Top Management of Omega do not feel that this system is working effectively as yet.

The Order Generation system is believed to be reasonably successful because it does provide the buyers with a great deal of meaningful information. However it is only as accurate as the input information used to create the report, which is the major failing.

The Goods Received system is fundamentally independent of two other systems. However incorrect movement data can result

in incorrect orders being placed by buyers. As a result, many of the criticisms levelled at this system are not really justified.

Table 87 lists the rating of factors believed to influence OR/MS success.

TABLE 87

FACTORS AFFECTING OR/MS SUCCESS AT COMPANY OMEGA

	Rating
CONTROLLING	
- Level of Top Management Support	M
- Level and Nature of Sponsorship	M
- Level of Systems Development	M
- Availability of Computer Support	M
ASSISTING	
- Influence and Reputation of OR/MS Group	M
- Relevance and Success of Projects	M
- Formalization of Procedures	M
- Level of Client Receptivity	N
- Nature and Competence of OR/MS Personnel	M

CHAPTER 10

ANALYSIS OF THE RESULTS OF THE FIELD STUDIES

The previous chapter presented the detailed results of the field studies which were conducted in ten South African companies. These results must now be examined more closely to determine the validity of the proposed model of OR/MS Diffusion in South Africa. This chapter is devoted to an analysis of each of the hypotheses incorporated in the model in the light of the data obtained in the field studies.

THE DIFFUSION OF OR/MS IN SOUTH AFRICAN BUSINESS

A model of the possible diffusion process of OR/MS activity in South African business was proposed in Chapter 7 of this thesis. The main hypotheses which constitute the model are as follows:

1. OR/MS Diffusion is an example of an Authority-Innovation Decision process and is a combination of two somewhat different processes superimposed upon one another. The Primary Process is the one in which Top Management makes the decision to run a Trial on OR/MS. It is hypothesised that this Process is controlled by the Receptivity of Top Management for OR/MS.

   The Secondary process is one in which Top Management and subordinates are exposed to in-company OR/MS projects and make the decision to adopt or reject OR/MS. This process is believed to be controlled by OR/MS Success.

2. The Primary Diffusion process is dependent upon the Receptivity of Top Management for Innovation in general and OR/MS in particular. Receptivity is a composite term designed to cover the first three stages of a normal diffusion process - Awareness, Interest, and Evaluation. It is hypothesised that Receptivity of Top Management in South African business is controlled by three factors, namely:

   - The influence of international parent companies or associates.

- The presence of professionally trained management with modern norms.
- The availability of EDP expertise with OR/MS experience

The Receptivity of Top Management will be low in an environment in which these three factors are absent. Conversely the Top Management of a company in which these three factors are present will be more favourably disposed towards OR/MS.

There are eight other factors which are believed to assist the Primary Diffusion Process.

3. The Secondary Diffusion process commences as soon as Top Management orders a Trial of OR/MS. If the Trial is a failure Top Management is likely to reject OR/MS and no further projects will take place. If the Trial is a success Top Management may make the decision to introduce OR/MS formally into the organization and subordinates will be forced to adopt OR/MS. Management will only decide to discontinue OR/MS if subsequent projects are not a success. Success therefore governs the Secondary Diffusion process of OR/MS.

It is hypothesised that OR/MS success is controlled by four factors in South African business:

- The level of Top Management support for OR/MS
- The level of sponsorship of OR/MS
- The level of systems development within the organization
- The accessibility of computer support

In an environment in which the effect of these four factors is pronounced OR/MS activity is likely to be extremely successful.

There are a further five factors which are believed to assist the Secondary Diffusion process.

4. Finally it is hypothesised that in South Africa there is a positive relationship between the Receptivity of Top Management in a company and the level of Systems Development within the company. Companies in which Information Systems development has been neglected will have a Top Management team which is hostile to Innovative Activity such as OR/MS.

The following sections are devoted to an examination of each of the hypotheses in the light of the findings of the Field Studies.

TOP MANAGEMENT RECEPTIVITY IN THE PRIMARY PROCESS

A Receptivity rating was performed on all members of Top Management. Four different levels of Receptivity were anticipated:

E - Enthusiastic

S - Supportive

I - Indifferent

H - Hostile

The Receptivity of Top Management varied from company to company and between members of the same company. Generally, members of the same Top Management team had similar levels of Receptivity although there were one or two companies in which significant differences in Receptivity of Top Management were observed.

The similarity of Receptivity ratings amongst the Top Managers of the same organization is probably due to the fact that promotion of Senior Managers to Top Management posts will be dependent upon the individual exhibiting the same norms as the existing members of Top Management. In view of this similarity it is possible to justify an overall Receptivity rating of a Top Management team based upon the observed Receptivity of individual members. The data in Table 88 lists the Receptivity of Top Management in all ten organizations and the overall Receptivity of each Top Management team as a whole. The table is arranged in order of decreasing overall Receptivity. OR/MS sponsors are indicated with an asterisk.

The levels of overall Receptivity are based upon the weighted contribution of Individual Receptivity and the perceived attitudes of Top Management as a whole during the Field Studies. The tendency of members of the same Top Management team to have similar Receptivities can be observed in many companies in the table. It appears that the greater the number of executives in the Top Management team the wider the spread of Receptivity. Company Alpha is a good example of an organization in which Receptivity varies significantly from manager to manager.

However the Enthusiastic support of the Chairman and Managing Director (also the sponsor) is sufficient to outweigh the negative attitudes of some members of management.

TABLE 88

RECEPTIVITY OF MEMBERS OF TOP MANAGEMENT

Company	Individual Receptivity	Overall Receptivity
Gamma	EEE*SS	E
Kappa	EESS	E-S
Epsilon	EE*SSS	E-S
Omega	EE*SSI	S
Alpha	~~EE*SSSSIIHH~~	S
Sigma	SSSS	S
Theta	SSSSII	S-I
Beta	SSSIIII*HH	I
Lambda	S*IHHH	I-H
Delta	S*SIHHHH	H

*Indicates Sponsor

The companies in Table 88 are now roughly ranked in terms of the overall Receptivity. This ranking merely indicates that the Top Management of Companies Gamma, Kappa, and Epsilon are more Receptive to Innovation than their counterparts in Beta, Lambda and Delta for example. In terms of the hypothesis linking various internal and environmental factors with Receptivity, the influence of the three factors that are believed to control Receptivity should be greater at the head of the table than at the tail. This hypothesis is tested in Table 89.

T A B L E 89

PRIMARY PROCESS - CONTROLLING FACTORS

AND RECEPTIVITY

Company	Overall Receptivity	Controlling Factors		
		Int. Parent	Prof. Management	EDP Expertise
Gamma	Enthusiastic	Moderate	Pronounced	Pronounced
Kappa	Enthusiastic-Supportive	Pronounced	Pronounced	Moderate
Epsilon	Enthusiastic-Supportive	Moderate	Pronounced	Pronounced
Omega	Supportive	Negligible	Moderate	Moderate
Alpha	Supportive	Moderate	Pronounced	Pronounced
Sigma	Supportive	Moderate	Moderate	Moderate
Theta	Supportive-Indifferent	Negligible	Moderate	Pronounced
Beta	Indifferent	Negligible	Moderate	Negligible
Lambda	Indifferent-Hostile	Negligible	Negligible	Negligible
Delta	Hostile	Negligible	Negligible	Negligible

The data in Table 89 confirms that if the companies are arranged in the order of Overall Top Management Receptivity then a distinct relationship between Receptivity and the three hypothesised Controlling factors can be observed. The companies in the table can be subdivided into three basic groups.

Companies Beta, Lambda, and Delta are controlled by Top Management teams that are indifferent or hostile to OR/MS. In all three companies the effect of the three Controlling factors is virtually negligible. The Top Management team in Beta is rated as Moderately Professional, but apart from this, none of the Controlling factors are observed.

On the other hand the three Controlling factors exert a significant influence in the companies at the top of the list - Gamma, Kappa and Epsilon. Each company is characterised by a similar rating of Controlling factors - two Pronounced and one Moderate - and the Receptivity of Top Management of these companies is correspondingly high.

The remaining companies - Omega, Alpha, Sigma, and Theta - appear to fill a middle zone in which the contribution of the Controlling factors is not as marked as it is in the companies at the top of the table. Company Alpha can be seen as the exception in this group, the contribution of the Controlling factors is such that a much higher overall Receptivity of Top Management would be anticipated.

generalization ?

On the basis of these results it appears that Top Management Receptivity for OR/MS in South Africa is controlled by three factors:

- Influence of International Parent
- Presence of Professionally Trained Top Management
- Availability of EDP expertise with OR/MS experience

which is in agreement with the original hypothesis.

There are several other factors which have been found to assist in increasing the Receptivity of Top Management for OR/MS. The contribution of these factors in the ten companies is shown in Table 90.

T A B L E 90

PRIMARY PROCESS - ASSISTING FACTORS AND RECEPTIVITY

Company	Assisting Factors						
	Innovative Exposure	Influence of Graduates	Use of Consultants	Use by Competition	Reduced Profits	Increased Size	Government Influence
Gamma	M 1	N	P 2	M	M	M	N
Kappa	M 1	M	N 0	N	M	M	N
Epsilon	P 2	M	P 2	M	N	M	M
Omega	M 1	N	N	M	M	N	N
Alpha	M 1	P	M	N	M	M	N
Sigma	M 1	M	M	M	M	M	M
Theta	M 1	N	N	M	M	M	N
Beta	N 0	M	N 0	M	M	P	N
Lambda	M 1	N	N 0	M	P	P	N
Delta	N 0	N	N 0	N	P	N	N

↑ what about this column?

With one exception, the data in Table 90 does not appear to display consistent patterns which would indicate that any of these factors control Receptivity. However, the first factor in the list "Exposure of Top Management to Innovation" may have a positive association with Receptivity. It is possible that this factor enjoys a correlative? relationship with one of the Controlling factors - i.e. "Influence of Professionally Trained Top Management". However in the South African environment this could well be an independent factor influencing Receptivity.

OR/MS SUCCESS IN THE SECONDARY PROCESS

The Primary Process of OR/MS Diffusion can end in one of two ways. Top Management can either make the decision to reject OR/MS entirely or alternatively can order a Trial OR/MS project to be carried out. The Secondary Process starts as soon as the Trial commences and the outcome of the process is dependent upon the success or failure of the Trial and other subsequent OR/MS projects, if any.

It is hypothesised that OR/MS success during the Secondary Process in South Africa is Controlled by four factors:

- The level of Top Management Support
- The level of Sponsorship
- The level of systems development in the organization
- The accessibility of computer support

what is it?

As the factors indicate there is a certain interrelationship between the Primary and Secondary process. A company with a high rating for Top Management Receptivity in the Primary Process may also display Pronounced Top Management support and sponsorship. Furthermore the level of Data Processing expertise is an important factor in the Primary Process whilst the accessibility of computer support is identified as a Controlling factor in the Secondary Process. Consequently if the Controlling factors in the Primary Process indicate that Top Management will be hostile to OR/MS, it follows that if OR/MS activities are introduced into the company they are unlikely to be a success.

In order to test the hypothesis linking OR/MS success with these four factors it is necessary to subdivide the OR/MS groups in terms of the perceived success of OR/MS projects. As Table 91 shows there appear to be three categories involved. The first contains groups which have consistently achieved ratings of "Moderate Success" or better in all projects. The second category includes groups that have been rated lower than a "Moderate Success" at least once by Top Management and at the same time have achieved at least one "Outstanding Success". The third and last category is made up of the remaining groups.

T A B L E 91

PERCEIVED SUCCESS OF OR/MS PROJECTS

Company Identification	Perceived Success Ratings		
	Project 1	Project 2	Project 3
Alpha	S+S+S+SSSSMMM	S+S+S+S+S+S+SSSM	S+S+SSSM
Gamma	S+S+S+M	S+SSS	SM
Epsilon	SSSSMM	S+S+SSSS	-
Theta	S+S+S+SSS	S+S+SMM	-
Kappa	S+SSM	NFF	SSN
Sigma	S+S+S+SS	NNFFF	NNNNF
Beta	MMMNNNNFF	SSNNFF	MN
Delta	SFF	-	-
Lambda	MFF	-	-
Omega	MMNFF	MMNNN	SMMMM

The data in the table highlights the fact that the four groups in the first category have been consistently successful. The performance of the OR/MS groups in companies Beta and Omega

in the third category has been consistently poor, whilst the groups in Delta and Lambda have yet to complete a project.

The hypothesis states that these patterns of failure and success are determined by four Controlling factors. The influence of the four factors is shown in Table 92.

TABLE 92

SECONDARY PROCESS - CONTROLLING FACTORS AND SUCCESS

Company	Success Rating	Controlling Factor			
		Top Management Support	Sponsor-ship	Systems Develop-ment	Computer Accessi-bility
Alpha	Generally Successful	Pronounced	Pronounced	Moderate	Pronounced
Gamma		Pronounced	Moderate	Pronounced	Pronounced
Epsilon		Pronounced	Moderate	Pronounced	Pronounced
Theta		Pronounced	Moderate	Pronounced	Pronounced
Kappa	Variable Success	Pronounced	Negligible	Pronounced	Moderate
Sigma		Moderate	Moderate	Moderate	Moderate
Beta	Generally Disappointing	Moderate	Negligible	Moderate	Negligible
Delta		Moderate	Negligible	Moderate	Negligible
Lambda		Negligible	Moderate	Negligible	Negligible
Omega		Moderate	Moderate	Moderate	Moderate

The table shows that the impact of the four factors diminishes as the level of success decreases. The groups which have been rated as generally successful operate in companies in which the influence of the four Controlling factors varies from Moderate to Pronounced. The unsuccessful groups are found in

seems out of place

environments where the effect of the four Controlling factors is very much reduced. The variable success of the OR/MS groups in Kappa and Sigma is in agreement with the level of influence of the four factors.

It appears therefore that the success of OR/MS activities in South African business is positively associated with four Controlling factors.

- Level of Top Management Support
- Level of Sponsorship
- Level of Systems Development
- Level of Computer Accessibility

This finding supports the hypothesis.

In addition to these four factors there are five other factors which have been found to influence OR/MS Success internationally. The influence of these factors is shown in Table 93.

Two of these Assisting Factors do appear to be positively associated with OR/MS success.

- The Influence and Reputation of the OR/MS group
- The Relevance and Success of Selected Projects

This finding is in agreement with the published research of the Northwestern Group who report that the status of successful groups is generally high, and that such groups achieve outstanding track records with relevant projects - "success breeds success". It

debatable whether these two factors stem from success or whether they are responsible for success. However the field studies showed two things very clearly. Firstly, groups with high status have a greater chance of successfully completing a project. Secondly, success in one project will enhance status and lay the foundation for further success.

TABLE 93

SECONDARY PROCESS - ASSISTING FACTORS AND SUCCESS

Company	Success Rating	Assisting Factors				
		Group Reputation	Project Success	Forma-lization	Client Receptivity	OR/MS Competence
Alpha Gamma Epsilon Theta	Generally Successful	M M P P → 1.5	P P P P → 2	M M N M	M M N M → .75	P P N P → 1.5
Kappa Sigma	Variable Success	M M → 1.0	P P → 2	M N	N M → .5	M M → 1
Beta Delta Lambda Omega	Generally Disappointing	N M N M → .5	M N N M → .5	N M N M	N N N N → 0	P M M M → 1.25

The most critical project is the Trial at the start of the Secondary Process. Success in the Trial virtually guarantees subsequent adoption by Top Management and, in addition, will increase the chances of adoption by subordinates.

It appears therefore that in addition to the Controlling factors previously discussed there are two additional factors which significantly influence OR/MS success in South Africa. There is a positive relationship between the Status or Reputation of the OR/MS group and Success; furthermore Success in itself is associated with increasing Success.

TOP MANAGEMENT RECEPTIVITY AND INFORMATION SYSTEMS DEVELOPMENT

The level of Information Systems Development has been shown to play an important part in determining the success of OR/MS activity in the Secondary Process. Furthermore it is hypothesised that there is a relationship between the Information Systems Development Rating in an organization and the Receptivity of the Top Management in that organization. If the Top Management of an organization is non-Receptive to Innovation, the level of Systems Development is likely to be low. Furthermore this hypothesis can be extended to individual departments within an organization. A departmental head who is less Receptive to innovation than his colleagues will have less well-developed systems within his department.

The justification of this hypothesis is simply that formal systems development is in itself an innovation, in the South African environment. Consequently a company that has neglected a fundamental aspect of its business is unlikely to be receptive to a total innovation such as OR/MS.

The ten companies in the field study have already been listed in descending order of estimated Overall Receptivity. This ranking is repeated in Table 94 and the various Information Systems rankings are included for each company.

T A B L E 94

TOP MANAGEMENT RECEPTIVITY AND INFORMATION SYSTEMS DEVELOPMENT

Company	Overall Receptivity	Information Systems Rating				
		LOCIS	PAOCIS	FOCIS	MOCIS	OVERALL
Gamma	Enthusiastic	0,71	0,87	0,93	0,71	0,82
Kappa	Enthusiastic-Supportive	0,85	0,75	0,93	0,71	0,86
Epsilon	Enthusiastic-Supportive	0,71	0,75	0,85	0,85	0,80
Omega	Supportive	0,71	0,50	0,80	0,71	0,70
Alpha	Supportive	0,85	0,37	0,65	0,71	0,68
Sigma	Supportive	0,43	0,25	0,60	0,43	0,45
Theta	Supportive-Indifferent	0,71	0,63	0,80	0,55	0,70
Beta	Indifferent	0,35	0,63	0,73	0,28	0,40
Lambda	Indifferent-Hostile	0,35	0,26	0,33	0,14	0,30
Delta	Hostile	0,35	0,13	0,33	0,28	0,29

The data in the table confirms the hypothesis that there is a relationship between the Receptivity of Top Management of a company and the level of Information Systems development in that company. The sample is not large enough to support more specific conclusions, but it would appear that the limiting Overall Information Systems Rating is about 0,50. A company which achieves Information Systems Ratings lower than 0,50 is likely to have a

Top Management team that is non-Receptive to innovative activity including OR/MS and Systems Development.

The results of the field studies also show that a significant difference in Receptivity Ratings within a company may be accompanied by widely differing ISR's.

The following companies serve as an example:

1. Company Beta. The PAOCIS and FOCIS systems achieve ratings of 0,63 and 0,73 whilst the LOCIS and MOCIS systems are rated at 0,35 and 0,28. Both PAOCIS and FOCIS are the responsibilities of the Financial Director who has the highest Receptivity in the company.

2. Company Alpha. The General Manager has been largely responsible for the development of the LOCIS and MOCIS systems, whilst the Financial Director has been responsible for FOCIS and PAOCIS. The General Manager is rated as an Enthusiastic supporter of OR/MS whilst the Financial Director is Indifferent to OR/MS. LOCIS and MOCIS ratings are 0,85 and 0,71, and FOCIS and PAOCIS are 0,65 and 0,37 respectively.

In essence, Systems Development in South Africa can be classed as an innovative activity. As a result a company which has a Top Management team with a high Receptivity rating is more likely to become involved in formal Systems Development than a

company in which Top Management is hostile to innovation.

The implications of this relationship are twofold. Firstly a company with poorly developed systems is unlikely to favour OR/MS activity. Furthermore, Systems Development is an important requirement for OR/MS Success in the Secondary Process and the combination of non-Receptive management and poor systems is almost certain to lead to OR/MS failure and rejection should the activity progress beyond the Prebirth Phase of the Life Cycle.

PRIMARY AND SECONDARY DIFFUSION PROCESSES

The fundamental hypothesis in this model of OR/MS Diffusion in South African Business is that there are two processes involved. The first, the Primary Process, is the one in which Top Management becomes aware of OR/MS and makes a decision either to have nothing more to do with OR/MS or alternatively to order a Trial of the activity. It is hypothesised that the Primary Process is dependent upon the Receptivity of Top Management for OR/MS.

The Secondary Process of OR/MS Diffusion begins once Top Management decide to put the activity to test. It is hypothesised that the adoption of OR/MS in the Secondary Process by Top Management and subordinates is a function of the success achieved by the OR/MS activity.

Primary Process

If we consider the Primary Diffusion Process first it is possible to conclude that OR/MS activities are unlikely to proceed beyond the Prebirth Phase of the Life Cycle in companies where Top Management is hostile or indifferent to Innovation. Furthermore it is believed that the effect of this hostility will extend into the Introductory Phase of the Life Cycle - which is the Trial Period of the Secondary Process.

The Top Management of three companies in the field studies emerge as being clearly indifferent or hostile to OR/MS - namely Beta, Delta, and Lambda. The details of OR/MS activity in these three companies is given in Table 95.

T A B L E 95

DETAILS OF OR/MS ACTIVITIES

Company	Overall Receptivity	OR/MS Life Cycle Phase	Primary Process	Secondary Process
Delta	Hostile	Prebirth Phase (1970-?)	Incomplete	-
Lambda	Indifferent-Hostile	Introductory (1969-?)	Complete 1969	Incomplete
Beta	Indifferent	Introductory (1970-?)	Complete 1970	Incomplete

Company Delta has a Top Management team which is openly Hostile towards OR/MS. After four years the OR/MS activity is still in the Prebirth Phase of the Life Cycle and the Primary Process is incomplete - i.e. Top Management have not yet decided on a Trial of

OR/MS. In Company Lambda the Prebirth Phase took three years to complete and the Introductory Phase (i.e. the Trial) has been going on for four years. Company Beta did not experience a Prebirth Phase (OR/MS started via an Externally Induced Process) but the Introductory Phase began in 1970 and had not been completed by November 1973.

This is in marked contrast with a company like Gamma which has a Top Management team rated as Enthusiastically-Supportive. The Primary Process in Gamma started in 1970 and ended in 1971, and the Introductory Phase of the Life Cycle took only one year (1971-1972).

Company Epsilon is another company in which Top Management is rated Enthusiastic-Supportive. In this company the OR/MS Life Cycle went straight from Prebirth to Transitional, with no OR/MS Trial.

The basic problem with the model of the Primary Process is that it is extremely difficult to historically analyse events associated with the Prebirth Phase of the Life Cycle. No records are kept of those situations where Top Management has decided to reject OR/MS without a trial - i.e. during the Primary Process. Company Delta is a fortunate example of Internally Induced OR/MS surviving in a Hostile environment. The only OR/MS activities that are likely to be encountered are those where Top Management is sufficiently Receptive to permit a Trial.

For this reason the activities in Lambda and Beta are included in this analysis of the Primary Process.

The Field Studies in Lambda and Beta showed clearly that although Top Management had verbally agreed to the Trial of OR/MS they had displayed no further interest in the matter. Consequently the Introductory Phases in Beta and Lambda are very similar to the Prebirth Phase in Delta.

In conclusion therefore it is reasonable to conclude that the Primary Process of Authority-Innovation Decisions on OR/MS in South Africa is dependent upon the Receptivity of Top Management for OR/MS.

Secondary Process

The final hypothesis which must be discussed relates to the factors which influence the outcome of the Secondary Process, i.e. the factors which govern the adoption of OR/MS by Top Management and subordinates. It has been suggested that the most critical factor in the Secondary Process is Success. This hypothesis is tested in Table 96 which gives the success ratings of the various groups in terms of the Secondary Process.

The table shows clearly that the Secondary Process is significantly influenced by OR/MS success - i.e. OR/MS activities are most likely to be genuinely adopted by Top Management and subordinates if their work is perceived as a success. It is possible that one or more of the OR/MS groups shown in the lower

half of the list may in fact be discontinued by Top Management as a result of continued failure.

TABLE 96

OR/MS SUCCESS AND ITS RELATION TO THE SECONDARY PROCESS

Company	Success Rating	Primary Process Complete	Secondary Process Complete
Alpha	Generally Successful	1967	1972
Gamma		1971	1973
Epsilon		1970	1973
Theta		1971	1972
Kappa	Variable Success	None	Incomplete
Sigma		1967	1969
Beta	Generally Disappointing	1970	Incomplete
Delta		Incomplete	-
Lambda		1969	Incomplete
Omega		1968	Incomplete

CONCLUSIONS

The results of the field studies reported in this chapter confirm that the Two Process Model of OR/MS Diffusion in South Africa is a valid representation of the manner in which OR/MS activities are likely to be introduced into and adopted by local organizations. There are a small number of additional features that must be introduced in order to make the model more realistic.

The Primary Diffusion Process corresponds to the Pre-birth Phase of the Life Cycle Model and the Top Management

Awareness - Interest - Evaluation Phases of Authority-Innovation Decision-making. During the Primary Process Top Management become aware of OR/MS and make the decision to reject the activity completely or to run an in-company Trial to examine its potential. The Primary Process is only complete once Top Management has decided to reject OR/MS or to run a Trial.

The Secondary Process of OR/MS diffusion will only commence if Top Management decides to run a Trial. The Secondary Process ends when Top Management rejects or discontinues further OR/MS activity or when OR/MS is genuinely adopted throughout the organization.

The Primary Process is controlled by Top Management's Receptivity for OR/MS. The higher the Receptivity of Top Management the more likely that a trial of OR/MS will be arranged. Receptivity in turn is dependent upon four factors:

- The Influence of International Companies on their South African Subsidiaries or Associates
- The degree to which the Top Management is Professionally trained
- The Influence of Data Processing Personnel with OR/MS expertise
- The level of exposure of Top Management to Innovation

Top Management teams of companies, in which the influence of these four factors is marked, will be extremely Receptive to OR/MS. Generally the Receptivity of members of Top Management

in an organization will be similar unless the executive team is large. If members of Top Management are Hostile or non-Receptive to innovation, the Status and Receptivity of the Sponsor will significantly influence the outcome of the Primary Process.

The Secondary Process is controlled by OR/MS success. If the Trial is a success Top Management is likely to introduce OR/MS into the organization and subordinates will be forced to adopt it. This is characteristic of an Authority-Innovation Decision process. If the Trial is a failure Top Management may order an additional Trial or may discontinue further OR/MS activity. If subsequent OR/MS projects are successful the level of Top Management Adoption will increase and the forced adoption by subordinates becomes genuine. If subsequent projects are repeated failures, which can be due to disguised Rejection by subordinates, it is possible that Top Management may be forced to discontinue OR/MS.

OR/MS Success is controlled by a number of factors:

- Level of Top Management Support
- Level of Sponsorship
- Level of Information Systems Development
- Availability of Computer Backup
- Status and Reputation of the OR/MS Group
- Perceived Success of OR/MS

It will be seen that Top Management Receptivity also plays a part in the Secondary Process. Non-Receptive Management are unlikely

to provide support or sponsorship. However, Receptive Top Management may also fail to provide support or sponsorship if they are unaware of the nature of these two factors.

Information Systems Development is a key factor throughout the Diffusion process. A company which is run by non-Receptive Top Management is unlikely to have well developed Information Systems, as Systems Development is still an innovative activity in many local companies. Therefore if an OR/MS activity should be established in such an environment, the chances of success and final adoption are minimal.

CHAPTER 11

CONCLUSIONS

Management Science or Operations Research (OR/MS) is a relatively recent development in International Business technology, which has already found application in many functional areas of management. Additional areas of possible application are proposed each year.

However, the growth of the discipline has been erratic. There have been failures of potentially sound applications. Like many innovations, the diffusion of OR/MS into Business has been resisted by Top Management and employees alike. On occasion resistance has been sufficiently strong to cause the disintegration or discontinuation of OR/MS activity. In addition there is a widening "Implementation Gap" between OR/MS techniques which are available and those that are actually being employed. The frequency of actual OR/MS application is far less than the potential indicates.

These erratic patterns of growth and unexploited potential growth have been the subject of American research during the past decade. A number of different diffusion models have been proposed to account for OR/MS success. Perhaps the best reported is the OR/MS Life Cycle Model which was developed at Northwestern University. This model is particularly interesting as research has been extended to include the diffusion of OR/MS in countries

outside America to highlight the various factors which can exert a significant effect on the diffusion process.

A milestone in the study of OR/MS diffusion occurred in 1973 when the University of Pittsburgh convened a conference on "The Implementation of OR/MS Models, Theory, Research and Application". Ten models of the implementation process were presented at the conference, several based on experimental data.[1] The Life Cycle Model of Radnor and Rubenstein appeared as one of the more complex of the hypothesised processes.

look this up + Schultz & Slevin (1975)

In their preface to the proceedings of the conference, published in 1975, the authors Schultz and Slevin make the following comment: "In no case does a model purport to explain the entire process of OR/MS development and utilization."[2] Each model approaches OR/MS from a different aspect and as a result there are significant differences between the various models.

The conference dealt mainly with the factors which influence Success once the decision to introduce OR/MS has been taken by Top Management. In the American environment OR/MS is no longer an innovation as far as Top Management is concerned. OR/MS techniques are now generally accepted and the majority of organizations have progressed beyond the Prebirth Phase of the Life Cycle.

In South Africa the situation is different. Although OR/MS groups exist in some companies, and although a number of

successful applications have been reported, to the majority of South African managers OR/MS is still an innovation.

The Two Process Model of OR/MS diffusion which was developed in this thesis has therefore stressed the importance of the Prebirth Phase of the Life Cycle. In view of the fairly limited attention that has been paid to this phase of the diffusion process by research groups in the United States, it has been necessary to base the Primary Process on the established Authority-Innovation Decision model of Rogers and Shoemaker.

The Primary Process expands the Prebirth Phase of the Northwestern Model. It is controlled by Top Management Receptivity for innovation, and is the most important phase of the Diffusion Process in South African business at this point in time. Receptivity in the Primary Process will also influence Top Management support in the Secondary Process.

However, the Two Process Model makes a very definite distinction between Receptivity and Support. In the Primary Process Receptivity defines the attitude of South African Top Management towards OR/MS. In the Secondary Process, Support defines the extent to which Top Management is prepared to endorse OR/MS. It is quite possible for a Receptive Top Management team to fail to provide the necessary Support.

The Secondary Process is Controlled by OR/MS Success. The field studies confirmed that a number of the factors which had

been found to influence Success in the United States also exert an affect in South Africa. In particular Top Management Support and Sponsorship are positively associated with Success. In local business Computer Availability and Information Systems Development appear to be two further factors which are critical determinants of OR/MS Success.

AREAS OF FURTHER RESEARCH

The field studies were performed in ten companies which were selected because they housed established OR/MS activities. Consequently, the Top Management of these organizations were representative of a set of South African managers who were already exposed to OR/MS. Receptivity has been used to define an attitude towards innovation in general and OR/MS in particular, but the concept has only been tested in companies where OR/MS already exists. In view of the fact that OR/MS in South Africa appears to be on the threshhold of rapid growth it is important to know whether there are companies that are simultaneously Receptive to innovation but opposed to OR/MS. This would increase the understanding of the Norms and Values of South African managers and would provide a broader understanding of the factors influencing Receptivity.

A further area of research would involve the testing of the Two Process Model, which has been built using in-depth case studies, on a larger population of companies using rapid sampling. This would seek to identify the fundamental factors influencing

could contact alumni from MBA programs etc

OR/MS diffusion in each organization, and to confirm the validity of the Model mathematically.

The field studies indicated that the majority of OR/MS activities analysed were instituted after 1969. Furthermore, the main areas of concentration appeared to be Statistical Analysis, Inventory Control, CPM/PERT Forecasting and Corporate Modelling. Many of the other OR/MS techniques identified earlier in this thesis such as Risk Analysis, Queueing, etc. were not encountered at all. The techniques most frequently used are supported locally by software available from computer manufacturers. A further area for research would be to define precisely how much original OR/MS work is being done in South Africa, and how much is being done merely by using the know-how of suppliers. This knowledge would be of assistance in forecasting future requirements of industry with regard to the training of OR/MS graduates, as well as the long-term development profile of OR/MS in South Africa.

OBSERVATIONS ARISING FROM THE FINDINGS

The findings of this thesis should be of interest to individuals concerned with the diffusion of OR/MS activity in South Africa. South African organizations must benefit from the application of OR/MS techniques which are used internationally with considerable success. It is important to understand how these techniques can be employed to maximum advantage.

What about the role of business consultants in SA?

It would appear that for some time to come the diffusion of OR/MS techniques into South African Business will be governed by the training, attitudes and background of the Top Management of local companies. The field studies showed clearly that the chances of introducing OR/MS into companies with Traditional Management are remote. Internal Evolutionary OR/MS in this type of company is unlikely to meet with much success and there is little chance of Externally Induced Growth.

The situation will not continue indefinitely as many local companies are actively seeking professionally trained managers. Greater emphasis on under - and post - graduate University business education and greater exposure to innovation should see the start of an era of trained managers who are Receptive to OR/MS. In the short term, however, there will continue to be companies which will reject OR/MS. When one considers that the OR/MS diffusion process really only started locally in the late 1960's, the progress that has been made to date has been significant. In the future the rate of diffusion will increase as South African Top Management becomes more Receptive towards innovation.

There will also be companies that introduce OR/MS activity and subsequently discontinue it. Generally rejection or discontinuation will be due to OR/MS failure, and failure will be caused by a lack of Top Management support and/or effective sponsorship, poorly developed systems, and the absence of computer backup. Each of these factors is important in achieving the

eventual adoption of OR/MS. If these factors are present an environment will be created which will facilitate the diffusion and subsequent adoption of OR/MS at all levels within the organization.

REFERENCES

CHAPTER 11

1 R.L. Schultz and D.P. Slevin, Implementing Operations Research Management Science (New York: American Elsevier, 1975)

2 Ibid., p. 9

A P P E N D I X B

RESULTS OF FIELD STUDY IN COMPANY ALPHA

COMPANY BACKGROUND

Company Alpha manufactures and imports engineering and mining equipment. It has long established connections with the mining industry in the Republic and is the South African agent for many American, Canadian and European companies. Company Alpha has been in operation in South Africa for nearly forty years and has achieved a satisfactory profit and sales record during this time. The company is quoted on the Johannesburg Stock Exchange but unfortunately does not disclose turnover figures in its year end figures. The profit performance for the company for the period 1969 to 1973 is given in Table 97. Estimated turnover for 1973 was approximately R32 million.

T A B L E 97

PROFIT PERFORMANCE FOR COMPANY ALPHA*

Year ending Feb. 28th	1969	1970	1971	1972	1973
Profit Before Tax (R000)	2 700	2 360	1 800	1 960	2 900

* Source: Company Records

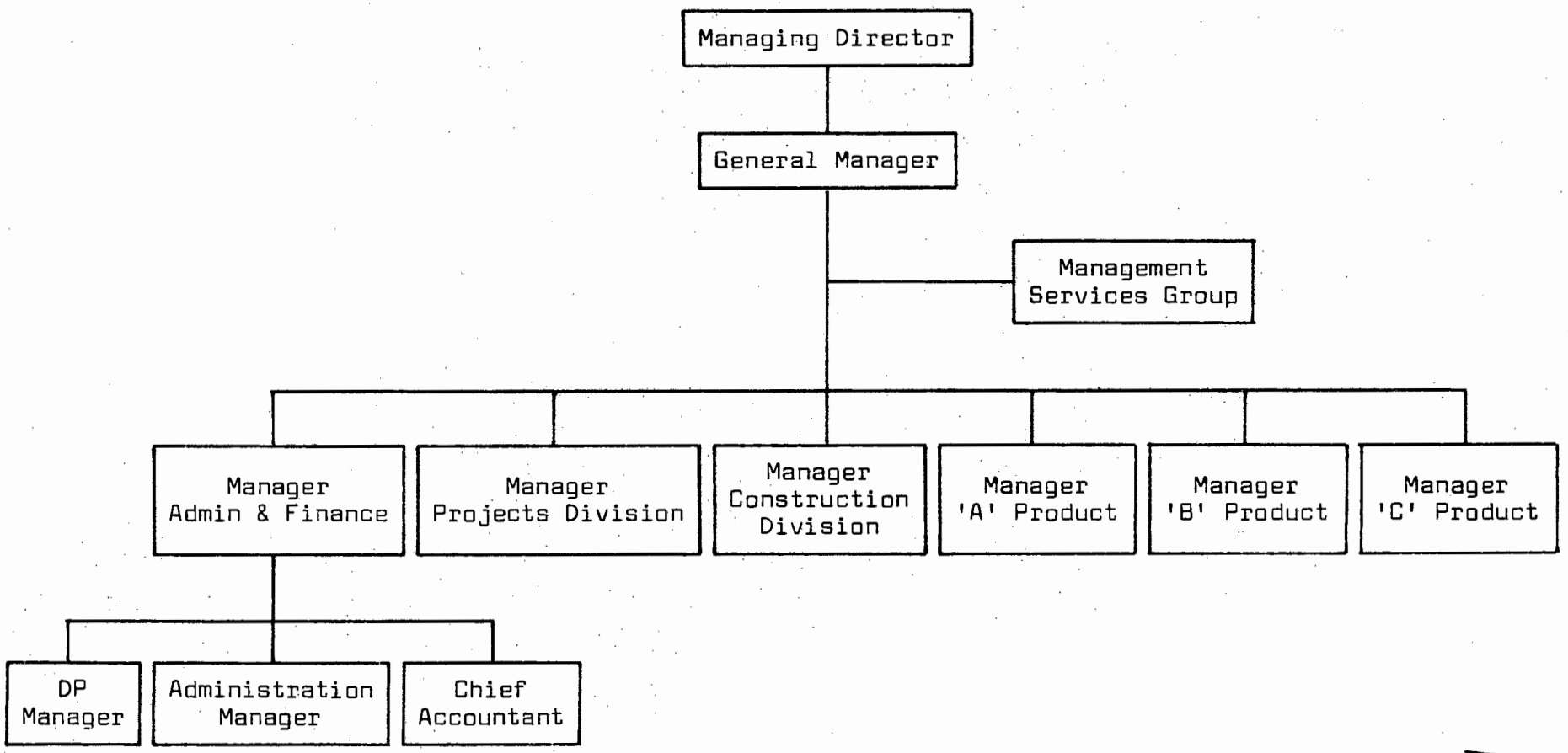
The significant drop in profits that occurred in 1971 was due to losses incurred during the closing down of a division which had shown losses virtually every year since 1965. Considerable quantities of stock had to be written off and the 130 employees in the division were relocated within the company.

The Head Office of Alpha is in Johannesburg and there are service branches in the Orange Free State and the Northern Cape. The company has five operating divisions, two of which are involved in the design and construction of engineering plant whilst the remainder manufacture and distribute various types of equipment. The company employs about 1 200 people, the majority of whom are located in the construction division.

The company has a permanent Management Service group which is part of Head Office and operates as a staff function within the company. The MS group is currently headed by a mechanical engineer with a Business Administration degree and contains four other personnel. The structure of the group is described in detail in a subsequent section. The group was originally responsible for the introduction of EDP into the company and the Data Processing manager reported to the Head of Management Services initially. This was a temporary arrangement and the existing organizational structure has not changed since 1971 except for the disappearance of the one division. The present organizational structure is shown diagrammatically in Figure 17.

F I G U R E 17

PARTIAL ORGANIZATION STRUCTURE OF COMPANY ALPHA*



* Source: Company records as at 30.11.73

Summary biographical details are presented in Table 98 which gives information about various managers in the organization. The information was obtained partially by interview and also by discussions with the Managing Director and General Managers.

Alpha does not have any overseas shareholders and as a result cannot draw on overseas expertise as far as Operational Research techniques are concerned. However the majority of the companies that are represented by Alpha in South Africa are international technical organizations with considerable expertise in the various areas of Management Science. Company Alpha has been introduced to many of the techniques of Quantitative Management over the years as a result of these connections.

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TABLE 98

SUMMARY BIOGRAPHICAL DETAILS OF MANAGEMENT PERSONNEL OF COMPANY ALPHA

(30.11.1973)

Managing Director: (65) Original founder of Alpha. Majority shareholder. B.Sc (Mechanical Engineer). Has particular expertise in Engineering Research and Development and was responsible for many of the early agencies that were obtained by Company Alpha. Has complete confidence in the General Manager.

General Manager: (37) Has been with Alpha since leaving University in 1960. B.Sc (Mechanical Engineering). General Manager for past six years. Responsible for creation of Management Science group and for introduction of EDP department. Travels abroad extensively.

Manager - Management Services: (36) Joined Alpha in 1968 after several years in America. B.Sc (Mechanical Engineering); M.B.A. Started the Management Services group, recruited staff. Personal friend of General Manager.

Manager - Administration and Finance: (48) Joined Alpha in 1955. Was partner in firm of auditors. C.A.(SA); C.W.A. Originally chief accountant reporting to Managing Director. Was promoted in 1967 when present General Manager was appointed.

TABLE 98 (continued)

Manager - Data Processing: (38) Joined Alpha in 1967 from IBM. No formal qualifications but has almost completed MBL Fifteen years experience in Data Processing.

Chief Accountant: (41) Joined Alpha in 1962 from U.K., where he had worked for ten years with a large construction firm. C.A.

Divisional Managers: (35-55) All have been with Alpha for over ten years. All except the Manager of the Construction Division (55) have University degrees in Mechanical and Civil Engineering.

Administration Manager: (58) CIS. Joined Alpha in 1946 after World War II.

HISTORY OF OR/MS ACTIVITY IN COMPANY ALPHA

The first formal OR/MS activities at Company Alpha were initiated in 1966 by the present General Manager who was manager of the Projects Division at the time. An engineer in the Projects Division was sent on a study course to America and Britain to examine the use of CPM/PERT techniques in the American Engineering Undustry. After his return he started working with ICL (who were ICT at the time) on computerized PERT methods for scheduling projects. The success of the first two PERT applications in early 1967 resulted in the appointment of a second engineer as Planning Officer for the Construction Division. Although employed in different Divisions the two engineers worked together on most projects from then on.

In May 1967 the present General Manager issued a Directive to all Divisions informing them of the Planning Team's existence and the availability of the expertise of the two Planning Engineers. All Division Managers were required to consult the Planning Team prior to embarking on projects with a capital expenditure in excess of R50 000. The majority of PERT applications continued to be in the Projects and Construction Divisions.

The company embarked on a further Operational Research programme in 1968 when a firm of management consultants were approached to assist in the introduction of a computerized accounting system. This was largely due to the newly appointed

General Manager who believed that the company was not generating the necessary financial operating information sufficiently accurately or rapidly for management decision making purposes. The consultants recommended the acquisition of an IBM 360/20 machine and assisted in the initial stages of staff selection and training.

During the process of the feasibility study the General Manager and the consultants examined the clerical stock control systems employed by Alpha. The stockturn on spares and engineering equipment for the previous three years had been less than 3 times per annum and the General Manager felt that it could be increased significantly. The consultants recommended a computerized stock recording and control system which they designed and installed during 1969 and 1970.

Two major appointments were made during 1968. The present Management Services manager was recruited to assist in the installation of the computer and to work with the consultants on the implementation of the inventory control system. The EDP manager came from IBM at the request of the General Manager whom he had known for some time.

The consultants, the Management Services manager - who was personal assistant to the General Manager at the time - and the EDP manager worked as a team on the computerization of the accounting and financial control systems. This was an ongoing programme which took most of 1969 and 1970 to complete. At the

end of 1969 two additional personnel were hired to carry out preparatory work on the inventory control system. These two analysts worked with the consultants on the inventory programme from the middle of 1970 until the end of 1971.

At the end of 1971 the General Manager's personal assistant was appointed Management Services manager, whilst the two analysts joined him to staff up the Management Services group. The computer installation became part of the Administration and Finance Division and the EDP manager reported to the manager of this Division. Two engineers, one from the Projects Division and the other from the Construction Division, were seconded to the Management Services group at the same time. These engineers had been running PERT/COST networks routinely on major projects in their respective divisions since 1966.

During the period between the end of 1971 and the end of 1973 the Management Services group continued to improve the stock control systems and to carry out scheduling projects for the Construction Division. New projects in Financial Forecasting and Long-Range Planning were started in 1972. The MS group leased an intelligent terminal from a Time Sharing company early in 1972 to assist in the building of Financial models of the company. This was a temporary measure as company Alpha had ordered an IBM 370/158 computer which was to arrive in 1974. This machine was intended to carry about five terminals which would be used for stock control, accounting and general Management Services applications.

THE OR/MS GROUP - LEADERSHIP AND PERSONNEL

The Management Services group was formally established in December 1971 with the following personnel:

- Management Services Manager - originally Personal Assistant to the General Manager
- Four Analysts - Two had been recruited in 1968 to implement the consultants' recommendations regarding the inventory control systems. The two engineers from the Planning Team were also transferred to the Management Services group.

The group reported directly to the General Manager and acted as a staff function to the six divisions. At the time the group was established CPM/PERT work had been carried out in Company Alpha for nearly six years and the implementation of the computerized Inventory Control System was virtually complete. The personnel in the group had already established reasonable relationships with the majority of Divisional Managers and had achieved a reputation for competent work by the time the group was formed.

A. Management Services Manager: (36) B.Sc (Mech. Eng.) (SA); M.B.A. (USA).

The Management Services Manager (MSM) was recruited by the General Manager in 1968 when he returned from America where he had been working in an Operational Research group in an Engineering Company for six years after getting his

MBA. The MS Manager had been at University with the General Manager prior to his departure for America and had known him for several years. He was attracted to Company Alpha because he believed that the company had tremendous potential and because he thought that the General Manager was competent, highly intelligent and was interested in the introduction of modern techniques into Alpha. He met and liked the Managing Director and realized that the General Manager had the support of the Managing Director.

When he was interviewed he was offered the job of Personal Assistant to the General Manager. Both he and the General Manager believed that it was too soon to introduce a formal Management Science group into the company, particularly as Company Alpha was involved in a considerable degree of change at the time. The firm of management consultants working in the company were introducing a computer as well as an inventory control system. His previous experience in America had enabled him to give a great deal of assistance in both projects and at the same time, get to know the company intimately. He was impressed by the fact that Alpha was already running CPM/PERT controls and had felt that the two members of the Planning Team were competent.

He had selected the two inventory control analysts after the consultants had furnished him with a short list of possible people. Neither had precise experience in the particular

application but both had a background which made training fairly easy. He had also interviewed the DP manager at the request of the General Manager and found him competent although inexperienced in Management Science applications.

As far as the other members of the company were concerned the MSM made the following observations:

(i) "Generally the task of the Management Services group has been made much easier because we have the support of both the General Manager and the Managing Director. The success of the General Manager as manager of the Projects Division as well as his very forceful personality has given him tremendous status in Alpha. The fact that he will obviously succeed the Managing Director in the next few years and his determination to introduce modern management techniques has made most members of senior management extremely receptive to the Management Services group."

(ii) "The decision to call the group Management Services instead of Management Science was deliberate as we are definitely a service function. We already had a record of success before the group was formed and had an established group of users. We did not think it was a good idea to label the group as something completely new."

(iii) "All the Engineering Division managers were committed to the inventory control exercise before it began as service on spares was catastrophic. We were able to get a great deal of support for the computer installation by introducing it as a tool which was required by the inventory control system. The success of the inventory exercise has had a tremendous effect on our support."

(iv) "The consultants we originally hired were competent but unpopular and most of Alpha were glad to see them go. Most divisions welcomed us without them."

(v) "Our main opposition has been from the Accounts Function. Although the Manager of Administration and Finance (MAF) is apparently committed to the Management Services group he has tried to sabotage us on several occasions. The Chief Accountant really believes we can help him and this has helped us with the MAF, in fact the entire Financial modelling exercise is being pushed by the Chief Accountant. The MAF has had to go along with us."

(vi) "I don't like the DP department where it is. Although the DP manager is a friend and very helpful, he is not able to do very much development work for us. The MAF obstructs him and his machine is small. The new

370 and the terminals will make life much easier for us although I think it will cause increased software development problems. Currently we do nearly all our work via the terminal to the bureau in town, this is really tremendous but it will have to stop when the 370 arrives. The MAF bitterly resents this expense."

(vii) "The GM and I originally wished to locate the computer in the Management Services department. The MD overruled us, and I think he was right. The MAF has been able to retain a great deal of status because of the fact that he controls the computer installation. Any way the machine is far too small for many of our Inventory Control and PERT applications. The DP manager is very good and the accounting and financial systems are really running well. However I am worried about the support we are going to get when we start using the 370."

(viii) "I think the fact that I am an engineer and that this is an engineering company has been a great help in getting the MS group off the ground. I did a lot of work in the States and have been able to suggest really useful improvements to many of the Divisional Managers. The chaps in the group are very good and have been accepted at most levels."

(ix) "We do seem to lack a financial man in the group. We are too technically orientated and I think this is holding us up on the development of the Financial Forecasting model. Fortunately the Chief Accountant has been useful but I do feel that we would be more effective and better received by the MAF if we could get hold of someone."

B. Management Services Group Analysts

There are four analysts in the MS group. Two of them are engineers who functioned as the CPM/PERT Planning Team prior to the creation of the MS group.

(a) Analyst 1: (42) B.Sc (Civil Eng.)

Started CPM/PERT in Alpha in 1966 on the instructions of the General Manager. Had previously worked in Projects Division for the future General Manager who at the time was Division Manager. He indicated that he had discussed the idea of CPM/PERT methods with the General Manager because he felt that they would be very useful in Alpha. As a result he was assigned the job of getting to know as much as he could about CPM/PERT. He spent six months overseas looking at various applications and then came back to South Africa to develop the techniques. He formed an association with the ICL Bureau in Johannesburg and still ran major methods through the Bureau.

Once CPM/PERT was successfully established he was able to convince the General Manager that a Planning Team should be formed in Alpha. An engineer from the Construction Division joined him in the middle of 1967 and the two of them worked together until 1971 when the Management Services group was formed. Apart from the normal problems of actually managing the networks on site they had never encountered any major opposition to CPM/PERT.

He had been glad to join the MS group as he had found less and less to do in the Planning Team due to the fact that CPM/PERT had become a fairly standard procedure in most divisions. The level of sophistication varied from division to division but most divisions no longer needed any help in running their programmes.

(i) "I have learned a great deal since joining the MS group and have tremendous respect for the MS manager. Although he is younger than I am he has far more experience than I have and I think he is doing a great job."

(ii) "I am currently working on the formalization of Long-Range Planning in the company. It is very much the same as the CPM/PERT work I used to do but far more interesting. We have a great deal

to do before we really start producing anything worthwhile. I find it harder to get managers to accept LRP and it is difficult to get their commitment. However I do feel that we would not be getting anywhere if we had not subjected ourselves to six years of planning discipline."

(b) Analyst 2: (48) B.Sc (Mech. Eng.)

Joined the Planning Team from Construction Division in 1967 and still does the majority of PERT/COST work for the Construction Division. He is fairly happy with the concept of the Management Services group but still regards the manager of the Construction Division as his superior. He likes the MS manager but does not feel he knows enough about the South African environment to understand the problems of planning.

(i) "The MS manager still thinks he is in America and doesn't know enough about local conditions to understand the problems involved in planning large projects in this country."

(ii) "Although I am situated in the MS group I really regard myself as part of the Planning Team and in the end am answerable to the Manager of Construction."

(iii) "I really haven't got time to get involved in any of the other work the group is doing. At the moment I am running three PERT/COST jobs and this in itself is a full-time occupation.

(c) Analyst 3: (28) B.Sc (Maths. Stats.)

Joined Company Alpha directly from University in December 1969. He had no industrial or commercial experience and was recruited to do the statistical analysis required for data preparation in the inventory control exercise. He initially worked with the consultants. When the consultants left he continued to work with Analyst 4 and the DP manager under the General Manager until the inventory control exercise was virtually complete in 1971.

He is currently working with the MS manager on the development of the Financial Forecasting package.

(i) "I was highly sick of the inventory control job when I left it. About 20 000 items, most of which were exceptions. However I learned a great deal about Alpha, the business we are in and the people. It is a good firm and I am really happy here."

(ii) "The Financial Modelling exercise is fascinating and is particularly interesting for me as I have

not been involved in this aspect of the business before. We are lucky that the Chief Accountant is willing to work with us as he has knowledge about certain aspects of financing which we lack."

(d) Analyst 4: (44) No Degree

This analyst had over fifteen years' experience in stores administration before joining Company Alpha. He had been in the main warehouse of Alpha for four years when he was selected by the consultants in mid 1970 to work on the inventory control project. He was sent on a series of "IMPACT" training programmes at IBM by the company together with one of the systems analysts in the DP department. Although most of the stock control systems were working by the end of 1971 he spent much of 1972 and 1973 changing, improving and adding on to the system. Company Alpha had a chief stock controller who was responsible for the procurement and supply of parts and spares for all divisions. Although the analyst and the controller initially had many disagreements on minor aspects of the system they managed to work together without conflict.

(i) "I and the stock controller have found that it is easier for me to get a Division Manager to agree to a change in the amount of consignment stock,

for example, than it is for him. The General Manager has been involved in the project from the beginning and he and the MS manager have credibility at Divisional Manager level. If any of the stock clerks in the divisions start to give us trouble it is fairly easy to bring them back to line."

(ii) "I think the most important aspect for me has been that I know inventory and I knew Alpha's inventory pretty well before the project started. I think I was able to get the GM and MS manager to make changes before problems occurred and this gave us greater acceptance. For example the system we run is similar to the IBM Impact system but differs very significantly, many of the modules in the system had to be changed because they wouldn't have worked."

(iii) "As soon as Division Managers realized what we were trying to do - we gave them a fairly intensive training course - they backed the system to the hilt. We have been successful and this has helped."

(iv) "One of the biggest problems has been that the computer we have has not been big enough to really get the maximum benefits from the control system.

> As soon as we get the new 370 we will be able to improve the system significantly. I am working with one of the systems engineers from IBM on the changeover at the moment. In fact I think I will be tied up on this for the next two or three years."

MANAGEMENT SCIENCE EXPERTISE AVAILABLE OUTSIDE COMPANY ALPHA

The Management Services group at Alpha have relied heavily upon the knowledge of the Management Services Manager and training supplied by Computer companies such as ICL for CPM/PERT and IBM for stock control. The Financial Modelling Exercise is being assisted by several OR analysts from the time sharing company concerned and the Chief Accountant who provides the financial expertise. Generally the initiative and the knowledge about new applications appears to stem from the General Manager and the Divisional Managers who see many new applications on trips to Europe and America.

For example, in November 1973 the MS manager was completing a project proposal for the use of Raw Materials Procurement packages in Division B which builds a great deal of special equipment under licence from an American company. The GM saw a system in operation in the American organization in 1971 and suggested to the MS manager that it could be integrated into the inventory control system. The MS manager visited the American plant in 1972 and spoke to various computer manufacturers who offered this

type of package. On his return to South Africa he commenced negotiations with IBM, ICL, and UNIVAC and after a certain amount of investigation was about to submit a proposal to the board of Alpha that the company should test out the IBM "PRINTS" system in Division B.

He made the comment at the time: "We realize that we are going to have to make several modifications to the package before we get it particularly effective. However I really think it will save the procurement officer in Division B a great deal of time and it will certainly make life easier for the Marketing Director. It is very difficult to put the benefits down in financial terms except that it will have a significant effect on our stockholding of finished goods."

SUCCESS OF OR/MS PROJECTS AT COMPANY ALPHA

At the end of 1973 Company Alpha was using recognised OR/MS techniques in four areas which were identified in Chapters 2 and 3 as being typical of those in which Management Science can be applied.

(a) Inventory Problems - Statistics, Probability Theory, Model Building, Simulation

(b) Sequencing and Co-ordination Problems - CPM/PERT

(c) Financial Planning Problems - Model Building, Simulation, Statistics

(d) Long Range Planning - Probability Theory, Simulation

In addition the company was thinking of using Statistics and Model Building to expand the Inventory Models to assist in Production Planning.

The management of Alpha were asked to evaluate the success or failure of OR/MS to solve management problems. In order to obtain results similar to those obtained by the Northwestern Research group, management (Managing Director, General Manager, Management Services Manager) were asked first to provide quantitative measurements of success or failure. The following measurements were obtained:

(a) Inventory Problems

In 1967 when the idea of Inventory Control was first introduced the stockturn on spares and general equipment had been less than 3. Although the company had considerable investment in raw materials there were no meaningful stockturn figures available. The following table shows the change in stockturn for spares, general equipment and raw materials between 1968 and 1973. The sales for each year are shown in terms of the 1968 figures. In some instances figures only became available as the control system was implemented.

T A B L E 99

SALES AND STOCKTURN FIGURES FOR COMPANY ALPHA‡

Year	Sales+	Stockturn (at cost) on		
		Finished Goods	Spares	Raw Materials
1968	100	2.9	2.9	n/a
1969	110	2.8	4.3	n/a
1970	132	3.6	5.2	n/a
1971	137	3.8	5.6	2.4
1972	148	4.3	6.4	3.1
1973*	163	4.2	5.9	3.1

* Estimated

+ 1968 as base year

‡ Source: Company Data

The marked improvement is readily apparent. The stock figures for spares and general equipment were combined in 1968 which accounts for the decline in turnover for general equipment in 1969. The decline in stockturn of spares in 1973 was due partially to increased difficulty in obtaining adequate supplies of steel from Iscor. The General Manager decided to increase stockholding to compensate for the uncertain lead time.

The success of the control system can be best confirmed by the fact that the total investment in various types of stock at Alpha went up by 10 per cent between 1968 and 1973 whilst sales increased by 63 per cent.

(b) Sequencing and Co-ordination Problems

It was virtually impossible for the Management of Alpha to put forward any firm figures for the improvements achieved by the introduction of CPM/PERT. Several rule of thumb figures were used by Management as a guide to the success of CPM/PERT techniques.

(i) The turnover of the Construction Division increased by 310 per cent between 1966 and 1973. The investment in plant only increased by 103 per cent and in people by 25 per cent.

(ii) The company had effectively reduced its payment of penalty clause charges by 68 per cent in the same time.

(iii) Division B had employed PERT/COST on the assembly of large items of equipment. Prior to the use of PERT/COST it was found that assembly usually took 3,5 to 4 months, by 1973 assembly had been reduced to 2 months. Although Management accepted that this was partially due to greater experience they believed a great deal of credit went to PERT/COST.

(c) Financial Planning

The Chief Accountant was able to give the bank his overdraft requirements for 1974 by the end of September 1973.

This statement showed the lowest, highest, and most likely overdraft levels month by month for the whole of 1974. The figures that had been produced in 1972 for 1973 had not been more than 30 per cent out on any one month.

The General Manager made the comment "I think the person who is most impressed is the Bank Manager."

(d) Long Range Planning

At the time of the field study there were no figures to use to examine the effectiveness of the Long Range Planning exercise.

RATING OF OR/MS PROJECTS IN COMPANY ALPHA

In addition to these measures of success, the managers in the company were also asked whether they believed that the four major projects tackled by the MS group and the MS group itself could be considered successful. The replies are given in Table 100.

Managers were permitted to answer in six possible ways:

Success +	Results of the project have more than justified the time and money put in
Success	The company has benefitted by the project and overall efficiency has improved as a result

T A B L E 100

SUCCESS OF MS ACTIVITIES AS PERCEIVED BY

MANAGERS OF COMPANY ALPHA

	Inventory Project	CPM/PERT Project	Fin. Forecasting Project	LRP Project
Managing Director	Success +	Success +	Success	Uncertain
General Manager	Success +	Success +	Success +	Uncertain
Financial Manager	Moderate Success	Moderate Success	Moderate Success	Uncertain
Chief Accountant	Success +	Success	Success +	Uncertain
Admin. Manager	Success	Success	Uncertain	Uncertain
Manager Projects	Moderate Success	Success +	Success	Uncertain
Manager Construction	Moderate Success	Success +	Uncertain	Uncertain
Manager Prod. 'A'	Success	Success	Uncertain	Uncertain
Manager Prod. 'B'	Success	Success +	Success	Uncertain
Manager Prod. 'C'	Success	Success	Uncertain	Uncertain

Moderate Success	The project has achieved certain minor improvements but no tangible benefits can be observed
No Change	The project has not adversely affected the running of the company
Uncertain	It is too early to observe the results of the project: I do not know enough about the project
Failure	In my opinion the project has not been a success

In the absence of readily quantifiable data, this attitudinal survey is interesting as it does give a profile of acceptance of Management Science at Company Alpha. The results are also interesting as they give an idea of the ranging levels of commitment to Management Science.

The most Successful project undertaken by the Management Services group is the CPM/PERT project rated as "Success +" by the Top Management of Alpha and its obvious Relative Advantage, Low Complexity, Easy Trialability, and definite Observability makes it extremely suitable for Diffusion. The Inventory project rated as "Success" also has made many of the positive diffusion characteristics, it is however more complex than the CPM/PERT project.

The Financial Forecasting project is acceptable to those

members of Top Managment who are involved. The remainder are unable to understand what it is to be used for and as a result it achieves a rating of "Moderate Success". The Long Range Planning project is still too novel to be understood.

PROCEDURALIZATION OF OR/MS PROJECTS

Proceduralization is believed to be positively associated with Success. At the time the study started the MS group operated fairly informally. New CPM/PERT projects were started as a result of verbal requests and the LRP project apparently came into being without any minutes or documentation. During discussions with the MS Manager the work at Northwestern was discussed and the MS Manager shortly afterwards started to formalize the activities of the group to a far greater extent. Although no Charter existed at the time a report was produced discussing the state of current OR work and proposed work. Permission for all future projects had to be formally obtained from the General Manager and reports had to be circulated to Divisional Managers describing anticipated research.

The Manager of the Construction Division said "Well now I know what the Long Range Planning project is all about. When you asked me last month I really had no idea." A quick survey of Divisional Managers showed that without exception they welcomed the increased formality. As the Financial and Administration Manager commented "At least we will be able to see what they are trying to do and how it affects our departments before it becomes law."

RELATIONSHIPS BETWEEN THE MANAGEMENT SERVICES GROUP AND TOP MANAGEMENT, DIVISIONAL MANAGERS, AND OTHER STAFF GROUPS

Table 100 of the previous section detailed the different perceptions of success of the Management Services group as seen by the ten senior members of Management in Company Alpha. The information in the table serves as a useful base to examine the relationships that existed between the MS group and the various divisions of Alpha. We have already mentioned the work carried out by the Northwestern Group which described the interfaces between the OR/MS activity and the organization itself.

The three main in-company interfaces were between Top Management, user departments, and other staff functions. Although these interfaces have already been partially described it is useful to summarize them here.

Interface with Top Management

The Managing Director and the General Manager of Company Alpha are completely committed to the Management Services group. Table 100 shows that the Managing Director rated two projects "Success +", one project "Success", one "Uncertain".

The Managing Director made the following comments about the MS group:

(i) "I think the MS group has delivered far more than it would have done, had the effort been distributed amongst various individuals in the firm."

(ii) "The MS group has achieved high status within the organization and I think you will find most managers will support the idea of a centralized activity to handle special projects."

(iii) "The General Manager and the Management Services Manager have my complete confidence. They have done such outstanding jobs in Data Processing and Stock Control that I really do not interfere except on questions of strategy. For example they challenged my decision to locate Data Processing in Administration and Finance. However I was aware that the Financial Manager was very worried about his future and was about to resign. It was a gesture of confidence in him that I admit could have backfired. Fortunately for me the Chief Accountant and the DP Manager got on well and, in fact, the Chief Accountant has become extremely interested in the entire Data Processing/Management Services exercise. As a result the DP Manager and the MS Manager get far more support from Administration and Finance than I originally anticipated."

It became clear during the interviews with the Managing Director that he had felt it necessary to protect the Administration and Finance Manager against the General Manager, MS Manager, and

DP Manager. "They are the same age, they talk the same language, and they constitute an extremely powerful group. This has been mainly responsible for the success of their efforts as they tend to steam roller opposition. However I think they underestimate the MAF and the fact that he has had about twenty years' experience in the business." He added that the Chief Accountant had originally helped the Data Processing Manager in computerizing the accounting and financial function and had been instrumental in bridging the gap between the Manager of Administration and Finance and the MS group. As a result he had not found it necessary to intervene as much as he originally anticipated.

The Managing Director originally wanted to have the MS group reporting directly to him. However he decided that he was not sufficiently competent in the field to make the necessary decisions. He had told the General Manager that any policy decisions and any new projects would have to be discussed with him and would have to be sanctioned by him before implementation. When asked whether the other managers in Company Alpha were aware of this he replied that he did not think so.

The General Manager at Company Alpha committed himself to the success of the MS group and as his perception of the results of the group indicate has achieved his original objective. Discussion with the General Manager showed that he was very much aware of the problems facing the MS group particularly with regard to the continued hostility of the Manager of the Administration and

Finance and the scepticism regarding the Long Range Planning project. He believed that the group would nevertheless continue to prosper if he left the company and made it clear that his main concern was the welfare of the company.

(i) "I know that many of the managers feel I have pushed the MS group too hard. However I really believe that we do need greater professionalism, and that firms in South Africa that want to survive the next few years will have to try to plan and budget more formally."

(ii) "I am trying to divorce myself from the group because I think it is established and the MS manager should be able to handle most situations without any help. I want the group to become identified as part of Alpha and not just one of my bright ideas. Future MS projects will have to gain the approval of the Management Committee, and I am just one of the members. There is obviously a need for formalization, for project proposals, evaluations and for the introduction of controls."

(iii) "Hopefully the company will start to generate new projects for the MS group in the future - however it doesn't seem to be happening at the moment. However members of the group do appear to be involved in developing existing projects which is reassuring."

(iv) "I think that the arrival of the new computer system is going to have a significant impact on the company and the MS group. They are going to tackle far more exciting projects than before and the overall result should be a far more meaningful Management Information System.

Interface with User Departments

Discussions with members of the various divisions in Company Alpha indicated that most members of Management were favourably impressed by the work done by the MS group. Managers believed that the company had benefitted particularly as a result of the Inventory and PERT exercises. The Long Range Planning project was regarded with scepticism - "I can't see how you can plan for contracts that haven't been put out to tender yet." However the general attitude was very much in favour of more formal planning. This was offset by the feeling that the GM and MS Manager were still experimenting and did not know what was going to come out of the project. All the managers believed that the group should be subjected to more controls and discipline and were not aware that the Managing Director controlled the activities of the group.

Shortly before the field study was completed the MS Manager circulated a memorandum regarding the proposed Raw Materials Requirements project. The discussion resulting from the memorandum was generally favourable, and the fact that the project would be discussed at the Management Committee meeting was well received. However one of the older managers made the remark "It doesn't mean

a thing. They are going to ask us what we think and then do what they want to do."

It appeared that most managers had a high regard for the competence of the General Manager who was universally credited with an exceptional mind and was an excellent engineer. The impact of the General Manager on the computerization of the financial and accounting systems had been dramatic as many of the managers had complained about the low level of financial information within Alpha for several years. Divisional Managers felt that the General Manager had provided the real drive behind the move to improve the systems and this enhanced his status significantly. An attitude of "If he thinks the group is a good idea then I am quite happy to go along with him," existed in the company.

The MS group Manager and the group members were identified as competent and their assistance was welcomed at all levels within the Divisions. Several of the Divisional Managers had ideas which they felt could be developed by the MS group but had not as yet proposed them formally because "they seem pretty fully occupied."

Interface with Staff Departments

The only non-technical interface was with the Finance and Administration group. This group was more complex than it appeared on the surface, as the attitude towards the MS group was in fact a combination of a favourable attitude displayed by the

DP and Accounting Managers and an antagonistic attitude displayed by the Manager of Administration and Finance (MAF) and the Administration Manager.

Although the MAF was reluctant to discuss his attitude towards the group it was evident that he had resented the involvement of management consultants initially and could not accept that it was necessary for the General Manager and the MS Manager to be involved in the redesign of accounting and financial systems prior to computerization. This attitude was mirrored in the behaviour of the Administration Manager. Neither of the two was convinced that the group was necessary although they both admitted that the Inventory project had been extremely successful.

The Data Processing Manager and the Chief Accountant were largely responsible for the continued existence of the MS group as they tended to assist the group in data gathering and computing without referring it to the MAF for approval. This was important as it meant that the MS group had access to service facilities without having to go through the MAF who inevitably could have delayed the projects concerned. This attitude was possibly largely due to the lack of computer knowledge on the part of the MAF and the Administration Manager who had virtually handed over responsibility for the installation to the Chief Accountant.

Both the DP Manager and the Chief Accountant felt that the arrival of the new 370 system would make life much easier for

the MS group. Terminal facilities would make access to the computer very simple and would also put an end to the most contentious item in the MS group's budget - the rental of the external time-sharing system. The MAF had made the point in an early interview that he thought it was ridiculous that the MS group was permitted to use outside time-sharing facilities as well as the services of the ICL Bureau for PERT projects when the in-house installation was not fully utilized. Attempts to explain why it was necessary to go outside had not convinced the MAF and this was a source of continual irritation. As soon as this expenditure disappeared the DP manager thought the MAF would be less irritated by the MS group.

The Chief Accountant indicated that he did not believe that the MS group would every really be accepted by the MAF and the Administration Manager until at least one member had a financial background.

EDP AVAILABILITY AT COMPANY ALPHA

Prior to the introduction of the IBM 360/20 computer at Company Alpha the company maintained a Hollerith Punched Card Installation. This was a small section which handled the processing of wages and salaries, invoicing and debtors statements. The EDP department carried out certain other minor accounting functions but the majority of accounting work was performed manually in the accounts department.

In mid-1968 the new IBM 360 computer system was brought on line after several months of parallel running. Initially only those applications which had run through the punched card department were processed by the computer but by 1969 the applications had expanded to handle virtually all the accounting work, as well as the stock recording portion of the Stock Control project. The 360 installation had magnetic tape storage, card input, and a line printer initially. The system was modified in 1970 when a faster printer was acquired as well as disc storage.

By 1969 it was apparent that although most of the accounting applications could be handled by the new computer system, it was impossible to run large PERT networks or the Forecasting portion of the Inventory Control system. There were two reasons for this. The staff of the EDP department were business application orientated and did not have experience in the design and operation of Management Science applications. Furthermore the installation was not large or powerful enough to handle the full Stock Control operation.

In 1972 the MS group leased a card input/line printer terminal from a company in Johannesburg and began to develop a realtime on-line Inventory Control System. The Financial Forecasting System was also introduced using a package obtained from the time-sharing company. As the accounting and financial reports became routine the DP Manager delegated his systems

analysts to work more closely with the MS analysts in preparation for the arrival of the 370 system which had been ordered in 1973. This system has a real time multiprogramming system which it was hoped, would be big enough to handle all the work projected by the MS group as well as routine accounting.

STATE OF SYSTEMS DEVELOPMENT

By the end of 1973 Company Alpha had successfully completed a number of Operational Research projects and planned to enhance and improve several of them. The Inventory Control System was designed to become an on-line interrogating system and the PERT/COST networks would be modified to accept terminal data input.

In addition to these specialized applications the company had developed an extremely effective and accurate accounting and financial information and control system. This system was virtually completely computerized and was backed by extremely thorough documentation and systems analysis. At the time the field work was completed, all divisional managers were receiving monthly operating statements eight days after the month end. These statements reported variances from budget and forecast anticipated performance for the financial year.

In terms of the four Operational Control Subsystems discussed in Chapter 5 it is possible to evaluate the Information Systems Rating achieved by Company Alpha.

LOGISTICS SUBSYSTEM

- Raw Materials Control

  All aspects of this subsystem currently carried out manually by all divisions. The computerization project being undertaken in Division 8 will, if successful, be used in the other divisions. Four modules out of a possible four are implemented.

- Production Control

  Individual divisions run their own control systems making use of PERT/COST where necessary. Three modules out of a possible five are implemented.

- Saleable Product Control

  All aspects of this subsystem are computerized and are all operational. Some are partially integrated with Accounting Control. The 370 system will be more sophisticated as it will permit on-line updating of records. Five modules out of five implemented.

$$\therefore \text{ LOCIS ISR } = \frac{4 + 3 + 5}{14} = \frac{12}{14} = 0{,}85$$

PHYSICAL ASSET SUBSYSTEM

- Property and Equipment Control

  Although a computerized Asset Register had been developed and is used by the company auditors no other aspects of this subsystem are formally operational. All new equipment is routinely checked and maintenance and repair is carried out

on a routine basis. Hence three out of five modules are implemented.

- Capital Projects Control

There are no formal systems in operation here. Therefore 0 out of three modules implemented.

$\therefore$ PAOCIS ISR $= \frac{3 + 0}{8} = \frac{3}{8} = 0,37$

FINANCIAL SUBSYSTEM

- Accounting Control

All aspects of this subsystem are computerized and exist routinely apart from pricing and costing which are handled manually by estimators. Eight out of nine modules implemented.

- Financial Control

Although only a few of these sections are operational considerable development work is being carried out. The Cash Control system is being used as a basis for the Financial Forecasting System. Two out of six implemented at present.

$\therefore$ FOCIS ISR $= \frac{8 + 2}{15} = \frac{10}{15} = 0,67$

MANPOWER SUBSYSTEM

- Payroll

Full payroll statistics for all divisions are being prepared routinely. Two out of a maximum of two modules are therefore implemented.

- Employee Benefits Control

  This is available as part of the Payroll package.

- Personnel Records Control

  Although Salary History and General Personnel Data is manually maintained by the Administration Manager there is no move to sophisticate this system. Only two out of four modules are maintained.

  $\therefore$ MOCIS ISR $= \frac{2 + 1 + 2}{7} = \frac{5}{7} = 0,71$

  The overall ISR for Company Alpha is therefore

  $$= \frac{30}{44} = 0,68$$

This is a fairly high Overall ISR for a South African organization and reveals a certain commitment to systems development on the part of Top Management.

As the analysis shows Company Alpha has attempted to develop the majority of subsystems depicted in the Operational Control System Classification. Virtually all these systems are computerized and the Data Bank has been created so that the Logistics, Accounting, and Manpower subsystems are partially integrated. The arrival of the 370 computer system with real-time updating facilities will enhance the system considerably.

The systems that are being planned will be as sophisticated as any that exist in South Africa. This in itself is an extremely favourable environment for the development and diffusion

of the MS group within Alpha. The systems that exist already are more than adequate to supply the MS group with the information it may require. The systems that will be introduced will draw heavily on the expertise of the MS group for successful implementation - it remains to be seen whether the company has adequate EDP support to get the systems running.

RECEPTIVITY OF ALPHA TOP MANAGEMENT TO OR/MS

The majority of members of Top Management at Company Alpha are Receptive towards innovation, modern management techniques and OR/MS activities. This attitude is largely as a result of the policy of the present Managing Director who has always impressed upon his staff the need to improve and modify the product line of Company Alpha. This policy has made Divisional Managers receptive to innovation, and regular visits to America and Europe and visits from parent companies abroad have served to keep managers up to date on changes in management techniques outside South Africa. The introduction of PERT/CPM, Computers, and Stock Control was regarded by most managers as inevitable as they had seen similar systems operating effectively in other organizations overseas.

Although several of the managers questioned the need for a MS group as such they did not query the value of Operational Research techniques. As the cost of the EDP operation and the MS group is reflected in corporate overhead, except for services and time actually booked out to a division, managers do not feel that their divisions are being unjustifiably loaded with unnecessary charges. The availability of expertise at no charge unless actually

used has undoubtedly made them more favourably orientated towards the idea of the MS group.

Most managers are aware that the early success of Company Alpha was due to the innovative activities of the Managing Director and there is an attitude in the company which will accept change provided it seems worthwhile. This is perhaps the most significant criticism of Long Range Planning - "How can you anticipate what you will be doing if you are always changing?"

The Manager of Administration and Finance has accepted that the strategy of Company Alpha is to look for gaps in the technological market and to exploit them. He does however believe that a great deal of money is wasted as a result and does not accept that innovation is justified without first carefully evaluating the possible costs. He is aware that the Managing Director and General Manager actually welcome his attitude and use him to screen out financially unsound projects. This attitude does however challenge the existence of the MS group as he believes it could be incorporated in the DP function and reduced in staff. He feels that the tendency to hide the expenditure on EDP and MS in corporate overhead inevitably leads to unnecessary expense. He appears to resent the fact that the MS Manager has access to the General Manager and as a result does not have to justify expenditure as thoroughly as the remaining managers. The proposal that all future MS projects will be submitted to the Management Committee meets with his approval.

In order to obtain a measure of the Receptivity of Top Management towards OR/MS, senior executives were asked a number of probing questions which assess attitudes towards Innovation. The results obtained are shown in Table 101 below.

T A B L E 101

RESULTS OF RECEPTIVITY RATINGS CONDUCTED AT COMPANY ALPHA

Executive	Receptivity
Managing Director	E
General Manager	E (Sponsor)
Financial Manager	I
Chief Accountant	S
Admin. Manager	H
Manager Projects	S
Manager Construction	H
Manager Prod. 'A'	S
Manager Prod. 'B'	I
Manager Prod. 'C'	S

The results show a significant different in the Levels of Receptivity exhibited by the various members of Top Management at Company Alpha. The Managing Director and General Manager are highly Innovative, have a good knowledge of OR/MS, and are receptive to change. The Administrative Manager, the Manager of Construction and the Financial Manager are typically Traditional managers and opposed to innovation. The Chief Accountant and Manager Projects are examples of managers with Modern norms who will favour OR/MS as they believe it will improve the operation of Company Alpha.

The Receptivity of the Divisional Managers varies slightly, but as a group they tend to be cautiously Receptive to OR/MS. As they are involved in the operating divisions of Company Alpha they would probably be more interested in a particular aspect of OR/MS which has practical application and visible benefits to their divisions.

The overall Receptivity of Top Management is Supportive and shows that the Top Management of Alpha as a whole could be expected to be favourably disposed towards OR/MS. The very high rating of the General Manager who has acted as the sponsor of OR/MS since its first introduction to Alpha demonstrates the importance of effective sponsorship at all stages during the Life Cycle.

EVALUATION OF FACTORS INFLUENCING TOP MANAGEMENT RECEPTIVITY TOWARDS OR/MS

Several factors are thought to influence the Receptivity of Top Management towards OR/MS. These factors are classified either as Controlling, or Assisting depending upon the influence they exert on Receptivity. The Rating procedure for the determination of the extent to which the various factors are present or absent is described in detail in Chapter 8. The rating of Company Alpha is shown below.

CONTROLLING	Score
- Influence of International Parent Company/ Associates	M
- Professionally Trained Top Managers	P
- Availability of EDP Expertise in OR/MS	P
ASSISTING	
- Top Management Exposure to Innovation	M
- Influence of Management Graduates	P
- Influence of International Consultants	M
- Use of OR/MS by Competition	N
- Increased Competition, Reduced Profits etc.	M
- Increased Size of Operation	M
- Government Involvement	N

EVALUATION OF FACTORS INFLUENCING OR/MS SUCCESS

The previous section in this Appendix indicated that Company Alpha had achieved a reasonable level of Success in all projects attempted. Apart from the Long Range Planning project which was still relatively new, the three projects that had been completed at the time of the field studies were rated at levels of "Success" and "Success +", whilst the Financial Forecasting project achieved a "Moderate Success" rating.

There are a number of factors which are believed to be associated with Success. These factors are identified either as Controlling or Assisting depending upon their influence in the determination of Success. The scoring of the various factors is shown below.

CONTROLLING	Score
- Level of Top Management Support	P
- Level and Nature of Sponsorship	P
- Level of Systems Development	M
- Availability of Computer Support	P
ASSISTING	
- Influence and Reputation of OR/MS group	M
- Relevance and Success of Projects	P
- Formalization of Procedures	M
- Level of Client Receptivity	M
- Nature and Competence of OR/MS Personnel	P

EVALUATION OF THE DEVELOPMENT OF OR/MS ACTIVITY IN COMPANY ALPHA

The introduction and development of Management Science activity in Company Alpha has been singularly successful. There is considerable support for the Management Services group and the group has carried out successful work. Although current projects are not progressing as well as had been anticipated, the status and stability of the MS group should be sufficient to achieve desired objectives.

The MS group at Company Alpha came into being as a result of an Internal Evolutionary Process as well as an Externally Induced Process. The present General Manager was responsible for the start of both procedures.

In an Internally Induced Process more and more use is made of OR techniques until there is enough support to create a formal OR/MS activity. The Planning Team which was responsible for

CPM/PERT projects within Alpha became part of the MS group when it was created. However by the time this happened the Planning Team had firmly established the success of CPM/PERT.

The General Manager, who had previously been responsible for the introduction of PERT/CPM and the creation of the Planning Team, then started the Inventory Project using outside consultants and two analysts. At the same time he recruited as his Personal Assistant, an executive with experience in engineering as well as Management Science. The consultants, the analysts, the General Manager and his Assistant constituted a powerful team which virtually ensured the success of the Inventory Project. By the end of 1971 there were two accepted OR applications within Alpha, and the formal establishment of the MS group completed the recognised cycle of the Internal Evolutionary Process.

However the Externally Induced Process of the introduction of a MS group postulates that a person with power and influence within the organization recognises potential areas of application for OR/MS. As a result of his influence a formal group is established generally with a substantial initial charter. The General Manager emerges as a very powerful sponsor of OR/MS in Company Alpha and even though it took five years from the introduction of CPM/PERT to the creation of the MS group the cycle corresponds to an Externally Induced Process with a time lag.

The OR/MS Sponsor

The General Manager has played a critical part in the introduction of OR/MS. In 1966 as Manager of the Projects Division he had achieved high status as an intelligent engineer with an outstanding record. This was sufficient to enable him to act as a powerful change agent when he introduced the concept of CPM/PERT. The obvious benefits of formal planning in Company Alpha contributed to his promotion to General Manager in 1967. By this time his record as an innovator was instrumental in getting the Managing Director to approve the purchase of a computer, the computerization of the accounting and financial systems, and the start of the Inventory Control project. To do this the General Manager recruited two personal friends of his own age to supply expertise which he did not have - the DP and MS managers - as well as two additional analysts. By 1971 when the MS group was formally created the status of both the General Manager and the members of the MS group were sufficiently high to ensure top management support. The only opposition came from the Manager of Administration and Finance who bitterly resented the intrusion of the General Manager into his sphere of activity. This opposition was partially overcome by allocating the DP department to the MAF, and thereby restoring the responsibility for development of information systems to the MAF. By this time most of the development work had been done and the systems were successfully installed.

The aspirations and background of the General Manager meet most of the criteria which are normally associated with Sponsorship. He had formal exposure to OR/MS technology and was orientated towards innovation. He had established himself securely in an organization where the technology favoured the development of OR/MS. The organization was sufficiently small to ensure that the General Manager could personally direct the implementation of OR/MS projects thereby ensuring their success and as a result enhancing his status in the eyes of the organization and the Managing Director. The history of the development of MS at Alpha shows that the success of the General Manager resulted from the success of the MS group and vice versa.

It was only after the group was formally established and the success of the General Manager was guaranteed that projects such as Financial Planning and Long Range Planning were introduced. The outcome of these projects was not as certain as the CPM/PERT and Inventory exercises but by this time the status of both the General Manager and the group was sufficiently high to run the risk of possible failure.

The Life Cycle of the MS Group in Company Alpha

The history of OR/MS activities in the Company between 1966 and 1973 offer a useful means of comparison with the concept of the Life Cycle of OR/MS groups.

Prebirth and Introductory Phases:

There appear to have been two portions of the Introductory phase:

1966-1967: The start of the CPM/PERT projects in the Projects and Construction Division. The allocation of the two analysts to develop applications within the two Divisions.

1968-1970: The start of the Inventory Control projects. The allocation of resources to engage consultants to work on the project.

In both instances, although the time span differs, Management was evaluating the specific OR/MS techniques being employed and had not committed itself to permanent establishment of either activities. The hiring of the General Manager's personal assistant in 1968 cannot be considered as a permanent allocation to OR/MS activities as this executive was involved in the computerization exercise.

Transitional Phase:

Here there are two portions of the Transitional phase in which Management has indicated the intention of using OR/MS in the decision-making processes of the organization. Although OR/MS is not a permanent organizational activity there is no time limit on its charter.

1967-1971: The creation of the Planning Team which drew on two engineers from the Construction and Projects Division.

The Primary Diffusion Process was completed in 1966 when the CPM/PERT projects were started. The Secondary Process was complete in 1973 when the MS group was firmly established in Company Alpha.

A P P E N D I X B

RESULTS OF FIELD STUDY IN COMPANY ALPHA

COMPANY BACKGROUND

Company Alpha manufactures and imports engineering and mining equipment. It has long established connections with the mining industry in the Republic and is the South African agent for many American, Canadian and European companies. Company Alpha has been in operation in South Africa for nearly forty years and has achieved a satisfactory profit and sales record during this time. The company is quoted on the Johannesburg Stock Exchange but unfortunately does not disclose turnover figures in its year end figures. The profit performance for the company for the period 1969 to 1973 is given in Table 97. Estimated turnover for 1973 was approximately R32 million.

T A B L E 97

PROFIT PERFORMANCE FOR COMPANY ALPHA*

Year ending Feb. 28th	1969	1970	1971	1972	1973
Profit Before Tax (R000)	2 700	2 360	1 800	1 960	2 900

* Source: Company Records

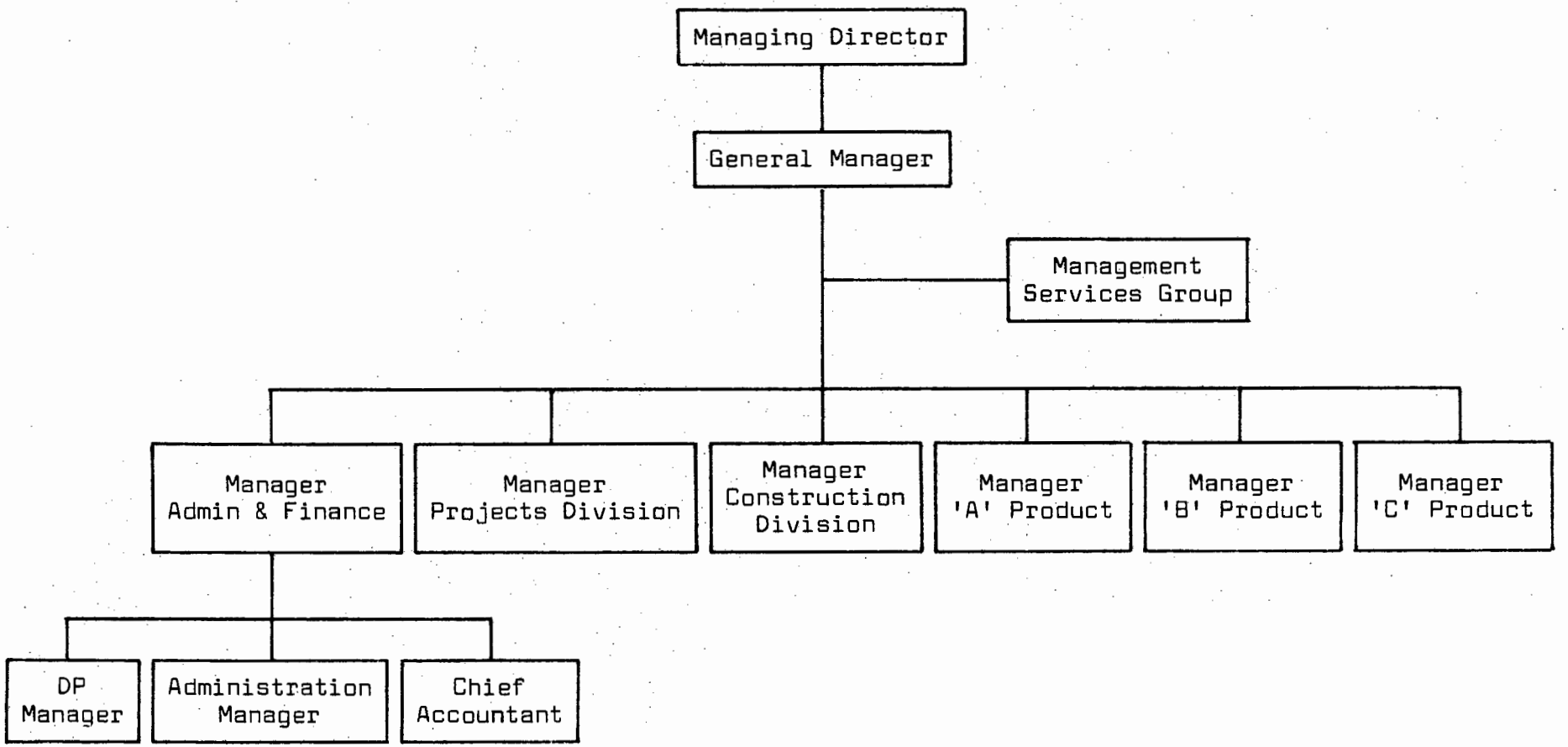
The significant drop in profits that occurred in 1971 was due to losses incurred during the closing down of a division which had shown losses virtually every year since 1965. Considerable quantities of stock had to be written off and the 130 employees in the division were relocated within the company.

The Head Office of Alpha is in Johannesburg and there are service branches in the Orange Free State and the Northern Cape. The company has five operating divisions, two of which are involved in the design and construction of engineering plant whilst the remainder manufacture and distribute various types of equipment. The company employs about 1 200 people, the majority of whom are located in the construction division.

The company has a permanent Management Service group which is part of Head Office and operates as a staff function within the company. The MS group is currently headed by a mechanical engineer with a Business Administration degree and contains four other personnel. The structure of the group is described in detail in a subsequent section. The group was originally responsible for the introduction of EDP into the company and the Data Processing manager reported to the Head of Management Services initially. This was a temporary arrangement and the existing organizational structure has not changed since 1971 except for the disappearance of the one division. The present organizational structure is shown diagrammatically in Figure 17.

F I G U R E 17

PARTIAL ORGANIZATION STRUCTURE OF COMPANY ALPHA*



* Source: Company records as at 30.11.73

Summary biographical details are presented in Table 98 which gives information about various managers in the organization. The information was obtained partially by interview and also by discussions with the Managing Director and General Managers.

Alpha does not have any overseas shareholders and as a result cannot draw on overseas expertise as far as Operational Research techniques are concerned. However the majority of the companies that are represented by Alpha in South Africa are international technical organizations with considerable expertise in the various areas of Management Science. Company Alpha has been introduced to many of the techniques of Quantitative Management over the years as a result of these connections.

T A B L E 98

SUMMARY BIOGRAPHICAL DETAILS OF MANAGEMENT PERSONNEL OF COMPANY ALPHA

(30.11.1973)

Managing Director: (65) Original founder of Alpha. Majority shareholder. B.Sc (Mechanical Engineer). Has particular expertise in Engineering Research and Development and was responsible for many of the early agencies that were obtained by Company Alpha. Has complete confidence in the General Manager.

General Manager: (37) Has been with Alpha since leaving University in 1960. B.Sc (Mechanical Engineering). General Manager for past six years. Responsible for creation of Management Science group and for introduction of EDP department. Travels abroad extensively.

Manager - Management Services: (36) Joined Alpha in 1968 after several years in America. B.Sc (Mechanical Engineering); M.B.A. Started the Management Services group, recruited staff. Personal friend of General Manager.

Manager - Administration and Finance: (48) Joined Alpha in 1955. Was partner in firm of auditors. C.A.(SA); C.W.A. Originally chief accountant reporting to Managing Director. Was promoted in 1967 when present General Manager was appointed.

TABLE 98 (continued)

Manager - Data Processing: (38) Joined Alpha in 1967 from IBM. No formal qualifications but has almost completed MBL Fifteen years experience in Data Processing.

Chief Accountant: (41) Joined Alpha in 1962 from U.K., where he had worked for ten years with a large construction firm. C.A.

Divisional Managers: (35-55) All have been with Alpha for over ten years. All except the Manager of the Construction Division (55) have University degrees in Mechanical and Civil Engineering.

Administration Manager: (58) CIS. Joined Alpha in 1946 after World War II.

HISTORY OF OR/MS ACTIVITY IN COMPANY ALPHA

The first formal OR/MS activities at Company Alpha were initiated in 1966 by the present General Manager who was manager of the Projects Division at the time. An engineer in the Projects Division was sent on a study course to America and Britain to examine the use of CPM/PERT techniques in the American Engineering Undustry. After his return he started working with ICL (who were ICT at the time) on computerized PERT methods for scheduling projects. The success of the first two PERT applications in early 1967 resulted in the appointment of a second engineer as Planning Officer for the Construction Division. Although employed in different Divisions the two engineers worked together on most projects from then on.

In May 1967 the present General Manager issued a Directive to all Divisions informing them of the Planning Team's existence and the availability of the expertise of the two Planning Engineers. All Division Managers were required to consult the Planning Team prior to embarking on projects with a capital expenditure in excess of R50 000. The majority of PERT applications continued to be in the Projects and Construction Divisions.

The company embarked on a further Operational Research programme in 1968 when a firm of management consultants were approached to assist in the introduction of a computerized accounting system. This was largely due to the newly appointed

General Manager who believed that the company was not generating the necessary financial operating information sufficiently accurately or rapidly for management decision making purposes. The consultants recommended the acquisition of an IBM 360/20 machine and assisted in the initial stages of staff selection and training.

During the process of the feasibility study the General Manager and the consultants examined the clerical stock control systems employed by Alpha. The stockturn on spares and engineering equipment for the previous three years had been less than 3 times per annum and the General Manager felt that it could be increased significantly. The consultants recommended a computerized stock recording and control system which they designed and installed during 1969 and 1970.

Two major appointments were made during 1968. The present Management Services manager was recruited to assist in the installation of the computer and to work with the consultants on the implementation of the inventory control system. The EDP manager came from IBM at the request of the General Manager whom he had known for some time.

The consultants, the Management Services manager - who was personal assistant to the General Manager at the time - and the EDP manager worked as a team on the computerization of the accounting and financial control systems. This was an ongoing programme which took most of 1969 and 1970 to complete. At the

end of 1969 two additional personnel were hired to carry out preparatory work on the inventory control system. These two analysts worked with the consultants on the inventory programme from the middle of 1970 until the end of 1971.

At the end of 1971 the General Manager's personal assistant was appointed Management Services manager, whilst the two analysts joined him to staff up the Management Services group. The computer installation became part of the Administration and Finance Division and the EDP manager reported to the manager of this Division. Two engineers, one from the Projects Division and the other from the Construction Division, were seconded to the Management Services group at the same time. These engineers had been running PERT/COST networks routinely on major projects in their respective divisions since 1966.

During the period between the end of 1971 and the end of 1973 the Management Services group continued to improve the stock control systems and to carry out scheduling projects for the Construction Division. New projects in Financial Forecasting and Long-Range Planning were started in 1972. The MS group leased an intelligent terminal from a Time Sharing company early in 1972 to assist in the building of Financial models of the company. This was a temporary measure as company Alpha had ordered an IBM 370/158 computer which was to arrive in 1974. This machine was intended to carry about five terminals which would be used for stock control, accounting and general Management Services applications.

THE OR/MS GROUP - LEADERSHIP AND PERSONNEL

The Management Services group was formally established in December 1971 with the following personnel:

- Management Services Manager - originally Personal Assistant to the General Manager
- Four Analysts - Two had been recruited in 1968 to implement the consultants' recommendations regarding the inventory control systems. The two engineers from the Planning Team were also transferred to the Management Services group.

The group reported directly to the General Manager and acted as a staff function to the six divisions. At the time the group was established CPM/PERT work had been carried out in Company Alpha for nearly six years and the implementation of the computerized Inventory Control System was virtually complete. The personnel in the group had already established reasonable relationships with the majority of Divisional Managers and had achieved a reputation for competent work by the time the group was formed.

A. Management Services Manager: (36) B.Sc (Mech. Eng.) (SA); M.B.A. (USA).

The Management Services Manager (MSM) was recruited by the General Manager in 1968 when he returned from America where he had been working in an Operational Research group in an Engineering Company for six years after getting his

MBA. The MS Manager had been at University with the General Manager prior to his departure for America and had known him for several years. He was attracted to Company Alpha because he believed that the company had tremendous potential and because he thought that the General Manager was competent, highly intelligent and was interested in the introduction of modern techniques into Alpha. He met and liked the Managing Director and realized that the General Manager had the support of the Managing Director.

When he was interviewed he was offered the job of Personal Assistant to the General Manager. Both he and the General Manager believed that it was too soon to introduce a formal Management Science group into the company, particularly as Company Alpha was involved in a considerable degree of change at the time. The firm of management consultants working in the company were introducing a computer as well as an inventory control system. His previous experience in America had enabled him to give a great deal of assistance in both projects and at the same time, get to know the company intimately. He was impressed by the fact that Alpha was already running CPM/PERT controls and had felt that the two members of the Planning Team were competent.

He had selected the two inventory control analysts after the consultants had furnished him with a short list of possible people. Neither had precise experience in the particular

application but both had a background which made training fairly easy. He had also interviewed the DP manager at the request of the General Manager and found him competent although inexperienced in Management Science applications.

As far as the other members of the company were concerned the MSM made the following observations:

(i) "Generally the task of the Management Services group has been made much easier because we have the support of both the General Manager and the Managing Director. The success of the General Manager as manager of the Projects Division as well as his very forceful personality has given him tremendous status in Alpha. The fact that he will obviously succeed the Managing Director in the next few years and his determination to introduce modern management techniques has made most members of senior management extremely receptive to the Management Services group."

(ii) "The decision to call the group Management Services instead of Management Science was deliberate as we are definitely a service function. We already had a record of success before the group was formed and had an established group of users. We did not think it was a good idea to label the group as something completely new."

(iii) "All the Engineering Division managers were committed to the inventory control exercise before it began as service on spares was catastrophic. We were able to get a great deal of support for the computer installation by introducing it as a tool which was required by the inventory control system. The success of the inventory exercise has had a tremendous effect on our support."

(iv) "The consultants we originally hired were competent but unpopular and most of Alpha were glad to see them go. Most divisions welcomed us without them."

(v) "Our main opposition has been from the Accounts Function. Although the Manager of Administration and Finance (MAF) is apparently committed to the Management Services group he has tried to sabotage us on several occasions. The Chief Accountant really believes we can help him and this has helped us with the MAF, in fact the entire Financial modelling exercise is being pushed by the Chief Accountant. The MAF has had to go along with us."

(vi) "I don't like the DP department where it is. Although the DP manager is a friend and very helpful, he is not able to do very much development work for us. The MAF obstructs him and his machine is small. The new

370 and the terminals will make life much easier for us although I think it will cause increased software development problems. Currently we do nearly all our work via the terminal to the bureau in town, this is really tremendous but it will have to stop when the 370 arrives. The MAF bitterly resents this expense."

(vii) "The GM and I originally wished to locate the computer in the Management Services department. The MD overruled us, and I think he was right. The MAF has been able to retain a great deal of status because of the fact that he controls the computer installation. Any way the machine is far too small for many of our Inventory Control and PERT applications. The DP manager is very good and the accounting and financial systems are really running well. However I am worried about the support we are going to get when we start using the 370."

(viii) "I think the fact that I am an engineer and that this is an engineering company has been a great help in getting the MS group off the ground. I did a lot of work in the States and have been able to suggest really useful improvements to many of the Divisional Managers. The chaps in the group are very good and have been accepted at most levels."

(ix) "We do seem to lack a financial man in the group. We are too technically orientated and I think this is holding us up on the development of the Financial Forecasting model. Fortunately the Chief Accountant has been useful but I do feel that we would be more effective and better received by the MAF if we could get hold of someone."

8. Management Services Group Analysts

There are four analysts in the MS group. Two of them are engineers who functioned as the CPM/PERT Planning Team prior to the creation of the MS group.

(a) Analyst 1: (42) B.Sc (Civil Eng.)

Started CPM/PERT in Alpha in 1966 on the instructions of the General Manager. Had previously worked in Projects Division for the future General Manager who at the time was Division Manager. He indicated that he had discussed the idea of CPM/PERT methods with the General Manager because he felt that they would be very useful in Alpha. As a result he was assigned the job of getting to know as much as he could about CPM/PERT. He spent six months overseas looking at various applications and then came back to South Africa to develop the techniques. He formed an association with the ICL Bureau in Johannesburg and still ran major methods through the Bureau.

Once CPM/PERT was successfully established he was able to convince the General Manager that a Planning Team should be formed in Alpha. An engineer from the Construction Division joined him in the middle of 1967 and the two of them worked together until 1971 when the Management Services group was formed. Apart from the normal problems of actually managing the networks on site they had never encountered any major opposition to CPM/PERT.

He had been glad to join the MS group as he had found less and less to do in the Planning Team due to the fact that CPM/PERT had become a fairly standard procedure in most divisions. The level of sophistication varied from division to division but most divisions no longer needed any help in running their programmes.

(i) "I have learned a great deal since joining the MS group and have tremendous respect for the MS manager. Although he is younger than I am he has far more experience than I have and I think he is doing a great job."

(ii) "I am currently working on the formalization of Long-Range Planning in the company. It is very much the same as the CPM/PERT work I used to do but far more interesting. We have a great deal

to do before we really start producing anything worthwhile. I find it harder to get managers to accept LRP and it is difficult to get their commitment. However I do feel that we would not be getting anywhere if we had not subjected ourselves to six years of planning discipline."

(b) Analyst 2: (48) B.Sc (Mech. Eng.)

Joined the Planning Team from Construction Division in 1967 and still does the majority of PERT/COST work for the Construction Division. He is fairly happy with the concept of the Management Services group but still regards the manager of the Construction Division as his superior. He likes the MS manager but does not feel he knows enough about the South African environment to understand the problems of planning.

(i) "The MS manager still thinks he is in America and doesn't know enough about local conditions to understand the problems involved in planning large projects in this country."

(ii) "Although I am situated in the MS group I really regard myself as part of the Planning Team and in the end am answerable to the Manager of Construction."

(iii) "I really haven't got time to get involved in any of the other work the group is doing. At the moment I am running three PERT/COST jobs and this in itself is a full-time occupation.

(c) Analyst 3: (28) B.Sc (Maths. Stats.)

Joined Company Alpha directly from University in December 1969. He had no industrial or commercial experience and was recruited to do the statistical analysis required for data preparation in the inventory control exercise. He initially worked with the consultants. When the consultants left he continued to work with Analyst 4 and the DP manager under the General Manager until the inventory control exercise was virtually complete in 1971.

He is currently working with the MS manager on the development of the Financial Forecasting package.

(i) "I was highly sick of the inventory control job when I left it. About 20 000 items, most of which were exceptions. However I learned a great deal about Alpha, the business we are in and the people. It is a good firm and I am really happy here."

(ii) "The Financial Modelling exercise is fascinating and is particularly interesting for me as I have

not been involved in this aspect of the business before. We are lucky that the Chief Accountant is willing to work with us as he has knowledge about certain aspects of financing which we lack."

(d) Analyst 4: (44) No Degree

This analyst had over fifteen years' experience in stores administration before joining Company Alpha. He had been in the main warehouse of Alpha for four years when he was selected by the consultants in mid 1970 to work on the inventory control project. He was sent on a series of "IMPACT" training programmes at IBM by the company together with one of the systems analysts in the DP department. Although most of the stock control systems were working by the end of 1971 he spent much of 1972 and 1973 changing, improving and adding on to the system. Company Alpha had a chief stock controller who was responsible for the procurement and supply of parts and spares for all divisions. Although the analyst and the controller initially had many disagreements on minor aspects of the system they managed to work together without conflict.

(i) "I and the stock controller have found that it is easier for me to get a Division Manager to agree to a change in the amount of consignment stock,

for example, than it is for him. The General Manager has been involved in the project from the beginning and he and the MS manager have credibility at Divisional Manager level. If any of the stock clerks in the divisions start to give us trouble it is fairly easy to bring them back to line."

(ii) "I think the most important aspect for me has been that I know inventory and I knew Alpha's inventory pretty well before the project started. I think I was able to get the GM and MS manager to make changes before problems occurred and this gave us greater acceptance. For example the system we run is similar to the IBM Impact system but differs very significantly, many of the modules in the system had to be changed because they wouldn't have worked."

(iii) "As soon as Division Managers realized what we were trying to do - we gave them a fairly intensive training course - they backed the system to the hilt. We have been successful and this has helped."

(iv) "One of the biggest problems has been that the computer we have has not been big enough to really get the maximum benefits from the control system.

> As soon as we get the new 370 we will be able to improve the system significantly. I am working with one of the systems engineers from IBM on the changeover at the moment. In fact I think I will be tied up on this for the next two or three years."

MANAGEMENT SCIENCE EXPERTISE AVAILABLE OUTSIDE COMPANY ALPHA

The Management Services group at Alpha have relied heavily upon the knowledge of the Management Services Manager and training supplied by Computer companies such as ICL for CPM/PERT and IBM for stock control. The Financial Modelling Exercise is being assisted by several OR analysts from the time sharing company concerned and the Chief Accountant who provides the financial expertise. Generally the initiative and the knowledge about new applications appears to stem from the General Manager and the Divisional Managers who see many new applications on trips to Europe and America.

For example, in November 1973 the MS manager was completing a project proposal for the use of Raw Materials Procurement packages in Division B which builds a great deal of special equipment under licence from an American company. The GM saw a system in operation in the American organization in 1971 and suggested to the MS manager that it could be integrated into the inventory control system. The MS manager visited the American plant in 1972 and spoke to various computer manufacturers who offered this

type of package. On his return to South Africa he commenced negotiations with IBM, ICL, and UNIVAC and after a certain amount of investigation was about to submit a proposal to the board of Alpha that the company should test out the IBM "PRINTS" system in Division B.

He made the comment at the time: "We realize that we are going to have to make several modifications to the package before we get it particularly effective. However I really think it will save the procurement officer in Division B a great deal of time and it will certainly make life easier for the Marketing Director. It is very difficult to put the benefits down in financial terms except that it will have a significant effect on our stockholding of finished goods."

SUCCESS OF OR/MS PROJECTS AT COMPANY ALPHA

At the end of 1973 Company Alpha was using recognised OR/MS techniques in four areas which were identified in Chapters 2 and 3 as being typical of those in which Management Science can be applied.

(a) Inventory Problems - Statistics, Probability Theory, Model Building, Simulation

(b) Sequencing and Co-ordination Problems - CPM/PERT

(c) Financial Planning Problems - Model Building, Simulation, Statistics

(d) Long Range Planning - Probability Theory, Simulation

In addition the company was thinking of using Statistics and Model Building to expand the Inventory Models to assist in Production Planning.

The management of Alpha were asked to evaluate the success or failure of OR/MS to solve management problems. In order to obtain results similar to those obtained by the Northwestern Research group, management (Managing Director, General Manager, Management Services Manager) were asked first to provide quantitative measurements of success or failure. The following measurements were obtained:

(a) Inventory Problems

In 1967 when the idea of Inventory Control was first introduced the stockturn on spares and general equipment had been less than 3. Although the company had considerable investment in raw materials there were no meaningful stockturn figures available. The following table shows the change in stockturn for spares, general equipment and raw materials between 1968 and 1973. The sales for each year are shown in terms of the 1968 figures. In some instances figures only became available as the control system was implemented.

T A B L E 99

SALES AND STOCKTURN FIGURES FOR COMPANY ALPHA[+]

Year	Sales[+]	Stockturn (at cost) on		
		Finished Goods	Spares	Raw Materials
1968	100	2.9	2.9	n/a
1969	110	2.8	4.3	n/a
1970	132	3.6	5.2	n/a
1971	137	3.8	5.6	2.4
1972	148	4.3	6.4	3.1
1973[*]	163	4.2	5.9	3.1

[*] Estimated

[+] 1968 as base year

[‡] Source: Company Data

The marked improvement is readily apparent. The stock figures for spares and general equipment were combined in 1968 which accounts for the decline in turnover for general equipment in 1969. The decline in stockturn of spares in 1973 was due partially to increased difficulty in obtaining adequate supplies of steel from Iscor. The General Manager decided to increase stockholding to compensate for the uncertain lead time.

The success of the control system can be best confirmed by the fact that the total investment in various types of stock at Alpha went up by 10 per cent between 1968 and 1973 whilst sales increased by 63 per cent.

(b) Sequencing and Co-ordination Problems

It was virtually impossible for the Management of Alpha to put forward any firm figures for the improvements achieved by the introduction of CPM/PERT. Several rule of thumb figures were used by Management as a guide to the success of CPM/PERT techniques.

(i) The turnover of the Construction Division increased by 310 per cent between 1966 and 1973. The investment in plant only increased by 103 per cent and in people by 25 per cent.

(ii) The company had effectively reduced its payment of penalty clause charges by 68 per cent in the same time.

(iii) Division B had employed PERT/COST on the assembly of large items of equipment. Prior to the use of PERT/COST it was found that assembly usually took 3,5 to 4 months, by 1973 assembly had been reduced to 2 months. Although Management accepted that this was partially due to greater experience they believed a great deal of credit went to PERT/COST.

(c) Financial Planning

The Chief Accountant was able to give the bank his overdraft requirements for 1974 by the end of September 1973.

This statement showed the lowest, highest, and most likely overdraft levels month by month for the whole of 1974. The figures that had been produced in 1972 for 1973 had not been more than 30 per cent out on any one month.

The General Manager made the comment "I think the person who is most impressed is the Bank Manager."

(d) Long Range Planning

At the time of the field study there were no figures to use to examine the effectiveness of the Long Range Planning exercise.

RATING OF OR/MS PROJECTS IN COMPANY ALPHA

In addition to these measures of success, the managers in the company were also asked whether they believed that the four major projects tackled by the MS group and the MS group itself could be considered successful. The replies are given in Table 100.

Managers were permitted to answer in six possible ways:

Success +	Results of the project have more than justified the time and money put in
Success	The company has benefitted by the project and overall efficiency has improved as a result

T A B L E 100

SUCCESS OF MS ACTIVITIES AS PERCEIVED BY MANAGERS OF COMPANY ALPHA

	Inventory Project	CPM/PERT Project	Fin. Forecasting Project	LRP Project
Managing Director	Success +	Success +	Success	Uncertain
General Manager	Success +	Success +	Success +	Uncertain
Financial Manager	Moderate Success	Moderate Success	Moderate Success	Uncertain
Chief Accountant	Success +	Success	Success +	Uncertain
Admin. Manager	Success	Success	Uncertain	Uncertain
Manager Projects	Moderate Success	Success +	Success	Uncertain
Manager Construction	Moderate Success	Success +	Uncertain	Uncertain
Manager Prod. 'A'	Success	Success	Uncertain	Uncertain
Manager Prod. 'B'	Success	Success +	Success	Uncertain
Manager Prod. 'C'	Success	Success	Uncertain	Uncertain

Moderate Success	The project has achieved certain minor improvements but no tangible benefits can be observed
No Change	The project has not adversely affected the running of the company
Uncertain	It is too early to observe the results of the project: I do not know enough about the project
Failure	In my opinion the project has not been a success

In the absence of readily quantifiable data, this attitudinal survey is interesting as it does give a profile of acceptance of Management Science at Company Alpha. The results are also interesting as they give an idea of the ranging levels of commitment to Management Science.

The most Successful project undertaken by the Management Services group is the CPM/PERT project rated as "Success +" by the Top Management of Alpha and its obvious Relative Advantage, Low Complexity, Easy Trialability, and definite Observability makes it extremely suitable for Diffusion. The Inventory project rated as "Success" also has made many of the positive diffusion characteristics, it is however more complex than the CPM/PERT project.

The Financial Forecasting project is acceptable to those

members of Top Managment who are involved. The remainder are unable to understand what it is to be used for and as a result it achieves a rating of "Moderate Success". The Long Range Planning project is still too novel to be understood.

PROCEDURALIZATION OF OR/MS PROJECTS

Proceduralization is believed to be positively associated with Success. At the time the study started the MS group operated fairly informally. New CPM/PERT projects were started as a result of verbal requests and the LRP project apparently came into being without any minutes or documentation. During discussions with the MS Manager the work at Northwestern was discussed and the MS Manager shortly afterwards started to formalize the activities of the group to a far greater extent. Although no Charter existed at the time a report was produced discussing the state of current OR work and proposed work. Permission for all future projects had to be formally obtained from the General Manager and reports had to be circulated to Divisional Managers describing anticipated research.

The Manager of the Construction Division said "Well now I know what the Long Range Planning project is all about. When you asked me last month I really had no idea." A quick survey of Divisional Managers showed that without exception they welcomed the increased formality. As the Financial and Administration Manager commented "At least we will be able to see what they are trying to do and how it affects our departments before it becomes law."

RELATIONSHIPS BETWEEN THE MANAGEMENT SERVICES GROUP AND TOP MANAGEMENT, DIVISIONAL MANAGERS, AND OTHER STAFF GROUPS

Table 100 of the previous section detailed the different perceptions of success of the Management Services group as seen by the ten senior members of Management in Company Alpha. The information in the table serves as a useful base to examine the relationships that existed between the MS group and the various divisions of Alpha. We have already mentioned the work carried out by the Northwestern Group which described the interfaces between the OR/MS activity and the organization itself.

The three main in-company interfaces were between Top Management, user departments, and other staff functions. Although these interfaces have already been partially described it is useful to summarize them here.

Interface with Top Management

The Managing Director and the General Manager of Company Alpha are completely committed to the Management Services group. Table 100 shows that the Managing Director rated two projects "Success +", one project "Success", one "Uncertain".

The Managing Director made the following comments about the MS group:

(i) "I think the MS group has delivered far more than it would have done, had the effort been distributed amongst various individuals in the firm."

(ii) "The MS group has achieved high status within the organization and I think you will find most managers will support the idea of a centralized activity to handle special projects."

(iii) "The General Manager and the Management Services Manager have my complete confidence. They have done such outstanding jobs in Data Processing and Stock Control that I really do not interfere except on questions of strategy. For example they challenged my decision to locate Data Processing in Administration and Finance. However I was aware that the Financial Manager was very worried about his future and was about to resign. It was a gesture of confidence in him that I admit could have backfired. Fortunately for me the Chief Accountant and the DP Manager got on well and, in fact, the Chief Accountant has become extremely interested in the entire Data Processing/Management Services exercise. As a result the DP Manager and the MS Manager get far more support from Administration and Finance than I originally anticipated."

It became clear during the interviews with the Managing Director that he had felt it necessary to protect the Administration and Finance Manager against the General Manager, MS Manager, and

DP Manager. "They are the same age, they talk the same language, and they constitute an extremely powerful group. This has been mainly responsible for the success of their efforts as they tend to steam roller opposition. However I think they underestimate the MAF and the fact that he has had about twenty years' experience in the business." He added that the Chief Accountant had originally helped the Data Processing Manager in computerizing the accounting and financial function and had been instrumental in bridging the gap between the Manager of Administration and Finance and the MS group. As a result he had not found it necessary to intervene as much as he originally anticipated.

The Managing Director originally wanted to have the MS group reporting directly to him. However he decided that he was not sufficiently competent in the field to make the necessary decisions. He had told the General Manager that any policy decisions and any new projects would have to be discussed with him and would have to be sanctioned by him before implementation. When asked whether the other managers in Company Alpha were aware of this he replied that he did not think so.

The General Manager at Company Alpha committed himself to the success of the MS group and as his perception of the results of the group indicate has achieved his original objective. Discussion with the General Manager showed that he was very much aware of the problems facing the MS group particularly with regard to the continued hostility of the Manager of the Administration and

Finance and the scepticism regarding the Long Range Planning project. He believed that the group would nevertheless continue to prosper if he left the company and made it clear that his main concern was the welfare of the company.

(i) "I know that many of the managers feel I have pushed the MS group too hard. However I really believe that we do need greater professionalism, and that firms in South Africa that want to survive the next few years will have to try to plan and budget more formally."

(ii) "I am trying to divorce myself from the group because I think it is established and the MS manager should be able to handle most situations without any help. I want the group to become identified as part of Alpha and not just one of my bright ideas. Future MS projects will have to gain the approval of the Management Committee, and I am just one of the members. There is obviously a need for formalization, for project proposals, evaluations and for the introduction of controls."

(iii) "Hopefully the company will start to generate new projects for the MS group in the future - however it doesn't seem to be happening at the moment. However members of the group do appear to be involved in developing existing projects which is reassuring."

(iv) "I think that the arrival of the new computer system is going to have a significant impact on the company and the MS group. They are going to tackle far more exciting projects than before and the overall result should be a far more meaningful Management Information System.

Interface with User Departments

Discussions with members of the various divisions in Company Alpha indicated that most members of Management were favourably impressed by the work done by the MS group. Managers believed that the company had benefitted particularly as a result of the Inventory and PERT exercises. The Long Range Planning project was regarded with scepticism - "I can't see how you can plan for contracts that haven't been put out to tender yet." However the general attitude was very much in favour of more formal planning. This was offset by the feeling that the GM and MS Manager were still experimenting and did not know what was going to come out of the project. All the managers believed that the group should be subjected to more controls and discipline and were not aware that the Managing Director controlled the activities of the group.

Shortly before the field study was completed the MS Manager circulated a memorandum regarding the proposed Raw Materials Requirements project. The discussion resulting from the memorandum was generally favourable, and the fact that the project would be discussed at the Management Committee meeting was well received. However one of the older managers made the remark "It doesn't mean

a thing. They are going to ask us what we think and then do what they want to do."

It appeared that most managers had a high regard for the competence of the General Manager who was universally credited with an exceptional mind and was an excellent engineer. The impact of the General Manager on the computerization of the financial and accounting systems had been dramatic as many of the managers had complained about the low level of financial information within Alpha for several years. Divisional Managers felt that the General Manager had provided the real drive behind the move to improve the systems and this enhanced his status significantly. An attitude of "If he thinks the group is a good idea then I am quite happy to go along with him," existed in the company.

The MS group Manager and the group members were identified as competent and their assistance was welcomed at all levels within the Divisions. Several of the Divisional Managers had ideas which they felt could be developed by the MS group but had not as yet proposed them formally because "they seem pretty fully occupied."

Interface with Staff Departments

The only non-technical interface was with the Finance and Administration group. This group was more complex than it appeared on the surface, as the attitude towards the MS group was in fact a combination of a favourable attitude displayed by the

DP and Accounting Managers and an antagonistic attitude displayed by the Manager of Administration and Finance (MAF) and the Administration Manager.

Although the MAF was reluctant to discuss his attitude towards the group it was evident that he had resented the involvement of management consultants initially and could not accept that it was necessary for the General Manager and the MS Manager to be involved in the redesign of accounting and financial systems prior to computerization. This attitude was mirrored in the behaviour of the Administration Manager. Neither of the two was convinced that the group was necessary although they both admitted that the Inventory project had been extremely successful.

The Data Processing Manager and the Chief Accountant were largely responsible for the continued existence of the MS group as they tended to assist the group in data gathering and computing without referring it to the MAF for approval. This was important as it meant that the MS group had access to service facilities without having to go through the MAF who inevitably could have delayed the projects concerned. This attitude was possibly largely due to the lack of computer knowledge on the part of the MAF and the Administration Manager who had virtually handed over responsibility for the installation to the Chief Accountant.

Both the DP Manager and the Chief Accountant felt that the arrival of the new 370 system would make life much easier for

the MS group. Terminal facilities would make access to the computer very simple and would also put an end to the most contentious item in the MS group's budget - the rental of the external time-sharing system. The MAF had made the point in an early interview that he thought it was ridiculous that the MS group was permitted to use outside time-sharing facilities as well as the services of the ICL Bureau for PERT projects when the in-house installation was not fully utilized. Attempts to explain why it was necessary to go outside had not convinced the MAF and this was a source of continual irritation. As soon as this expenditure disappeared the DP manager thought the MAF would be less irritated by the MS group.

The Chief Accountant indicated that he did not believe that the MS group would every really be accepted by the MAF and the Administration Manager until at least one member had a financial background.

EDP AVAILABILITY AT COMPANY ALPHA

Prior to the introduction of the IBM 360/20 computer at Company Alpha the company maintained a Hollerith Punched Card Installation. This was a small section which handled the processing of wages and salaries, invoicing and debtors statements. The EDP department carried out certain other minor accounting functions but the majority of accounting work was performed manually in the accounts department.

In mid-1968 the new IBM 360 computer system was brought on line after several months of parallel running. Initially only those applications which had run through the punched card department were processed by the computer but by 1969 the applications had expanded to handle virtually all the accounting work, as well as the stock recording portion of the Stock Control project. The 360 installation had magnetic tape storage, card input, and a line printer initially. The system was modified in 1970 when a faster printer was acquired as well as disc storage.

By 1969 it was apparent that although most of the accounting applications could be handled by the new computer system, it was impossible to run large PERT networks or the Forecasting portion of the Inventory Control system. There were two reasons for this. The staff of the EDP department were business application orientated and did not have experience in the design and operation of Management Science applications. Furthermore the installation was not large or powerful enough to handle the full Stock Control operation.

In 1972 the MS group leased a card input/line printer terminal from a company in Johannesburg and began to develop a realtime on-line Inventory Control System. The Financial Forecasting System was also introduced using a package obtained from the time-sharing company. As the accounting and financial reports became routine the DP Manager delegated his systems

analysts to work more closely with the MS analysts in preparation for the arrival of the 370 system which had been ordered in 1973. This system has a real time multiprogramming system which it was hoped, would be big enough to handle all the work projected by the MS group as well as routine accounting.

STATE OF SYSTEMS DEVELOPMENT

By the end of 1973 Company Alpha had successfully completed a number of Operational Research projects and planned to enhance and improve several of them. The Inventory Control System was designed to become an on-line interrogating system and the PERT/COST networks would be modified to accept terminal data input.

In addition to these specialized applications the company had developed an extremely effective and accurate accounting and financial information and control system. This system was virtually completely computerized and was backed by extremely thorough documentation and systems analysis. At the time the field work was completed, all divisional managers were receiving monthly operating statements eight days after the month end. These statements reported variances from budget and forecast anticipated performance for the financial year.

In terms of the four Operational Control Subsystems discussed in Chapter 5 it is possible to evaluate the Information Systems Rating achieved by Company Alpha.

LOGISTICS SUBSYSTEM

- Raw Materials Control

  All aspects of this subsystem currently carried out manually by all divisions. The computerization project being undertaken in Division B will, if successful, be used in the other divisions. Four modules out of a possible four are implemented.

- Production Control

  Individual divisions run their own control systems making use of PERT/COST where necessary. Three modules out of a possible five are implemented.

- Saleable Product Control

  All aspects of this subsystem are computerized and are all operational. Some are partially integrated with Accounting Control. The 370 system will be more sophisticated as it will permit on-line updating of records. Five modules out of five implemented.

$$\therefore \text{ LOCIS ISR } = \frac{4 + 3 + 5}{14} = \frac{12}{14} = 0{,}85$$

PHYSICAL ASSET SUBSYSTEM

- Property and Equipment Control

  Although a computerized Asset Register had been developed and is used by the company auditors no other aspects of this subsystem are formally operational. All new equipment is routinely checked and maintenance and repair is carried out

on a routine basis. Hence three out of five modules are implemented.

- Capital Projects Control

There are no formal systems in operation here. Therefore 0 out of three modules implemented.

$$\therefore \text{ PAOCIS ISR } = \frac{3 + 0}{8} = \frac{3}{8} = 0,37$$

FINANCIAL SUBSYSTEM

- Accounting Control

All aspects of this subsystem are computerized and exist routinely apart from pricing and costing which are handled manually by estimators. Eight out of nine modules implemented.

- Financial Control

Although only a few of these sections are operational considerable development work is being carried out. The Cash Control system is being used as a basis for the Financial Forecasting System. Two out of six implemented at present.

$$\therefore \text{ FOCIS ISR } = \frac{8 + 2}{15} = \frac{10}{15} = 0,67$$

MANPOWER SUBSYSTEM

- Payroll

Full payroll statistics for all divisions are being prepared routinely. Two out of a maximum of two modules are therefore implemented.

- Employee Benefits Control

  This is available as part of the Payroll package.

- Personnel Records Control

  Although Salary History and General Personnel Data is manually maintained by the Administration Manager there is no move to sophisticate this system. Only two out of four modules are maintained.

$\therefore$ MOCIS ISR $= \frac{2 + 1 + 2}{7} = \frac{5}{7} = 0,71$

The overall ISR for Company Alpha is therefore

$$= \frac{30}{44} = 0,68$$

This is a fairly high Overall ISR for a South African organization and reveals a certain commitment to systems development on the part of Top Management.

As the analysis shows Company Alpha has attempted to develop the majority of subsystems depicted in the Operational Control System Classification. Virtually all these systems are computerized and the Data Bank has been created so that the Logistics, Accounting, and Manpower subsystems are partially integrated. The arrival of the 370 computer system with real-time updating facilities will enhance the system considerably.

The systems that are being planned will be as sophisticated as any that exist in South Africa. This in itself is an extremely favourable environment for the development and diffusion

of the MS group within Alpha. The systems that exist already are more than adequate to supply the MS group with the information it may require. The systems that will be introduced will draw heavily on the expertise of the MS group for successful implementation - it remains to be seen whether the company has adequate EDP support to get the systems running.

RECEPTIVITY OF ALPHA TOP MANAGEMENT TO OR/MS

The majority of members of Top Management at Company Alpha are Receptive towards innovation, modern management techniques and OR/MS activities. This attitude is largely as a result of the policy of the present Managing Director who has always impressed upon his staff the need to improve and modify the product line of Company Alpha. This policy has made Divisional Managers receptive to innovation, and regular visits to America and Europe and visits from parent companies abroad have served to keep managers up to date on changes in management techniques outside South Africa. The introduction of PERT/CPM, Computers, and Stock Control was regarded by most managers as inevitable as they had seen similar systems operating effectively in other organizations overseas.

Although several of the managers questioned the need for a MS group as such they did not query the value of Operational Research techniques. As the cost of the EDP operation and the MS group is reflected in corporate overhead, except for services and time actually booked out to a division, managers do not feel that their divisions are being unjustifiably loaded with unnecessary charges. The availability of expertise at no charge unless actually

used has undoubtedly made them more favourably orientated towards the idea of the MS group.

Most managers are aware that the early success of Company Alpha was due to the innovative activities of the Managing Director and there is an attitude in the company which will accept change provided it seems worthwhile. This is perhaps the most significant criticism of Long Range Planning - "How can you anticipate what you will be doing if you are always changing?"

The Manager of Administration and Finance has accepted that the strategy of Company Alpha is to look for gaps in the technological market and to exploit them. He does however believe that a great deal of money is wasted as a result and does not accept that innovation is justified without first carefully evaluating the possible costs. He is aware that the Managing Director and General Manager actually welcome his attitude and use him to screen out financially unsound projects. This attitude does however challenge the existence of the MS group as he believes it could be incorporated in the DP function and reduced in staff. He feels that the tendency to hide the expenditure on EDP and MS in corporate overhead inevitably leads to unnecessary expense. He appears to resent the fact that the MS Manager has access to the General Manager and as a result does not have to justify expenditure as thoroughly as the remaining managers. The proposal that all future MS projects will be submitted to the Management Committee meets with his approval.

In order to obtain a measure of the Receptivity of Top Management towards OR/MS, senior executives were asked a number of probing questions which assess attitudes towards Innovation. The results obtained are shown in Table 101 below.

T A B L E 101

RESULTS OF RECEPTIVITY RATINGS CONDUCTED AT COMPANY ALPHA

Executive	Receptivity
Managing Director	E
General Manager	E (Sponsor)
Financial Manager	I
Chief Accountant	S
Admin. Manager	H
Manager Projects	S
Manager Construction	H
Manager Prod. 'A'	S
Manager Prod. 'B'	I
Manager Prod. 'C'	S

The results show a significant different in the Levels of Receptivity exhibited by the various members of Top Management at Company Alpha. The Managing Director and General Manager are highly Innovative, have a good knowledge of OR/MS, and are receptive to change. The Administrative Manager, the Manager of Construction and the Financial Manager are typically Traditional managers and opposed to innovation. The Chief Accountant and Manager Projects are examples of managers with Modern norms who will favour OR/MS as they believe it will improve the operation of Company Alpha.

The Receptivity of the Divisional Managers varies slightly, but as a group they tend to be cautiously Receptive to OR/MS. As they are involved in the operating divisions of Company Alpha they would probably be more interested in a particular aspect of OR/MS which has practical application and visible benefits to their divisions.

The overall Receptivity of Top Management is Supportive and shows that the Top Management of Alpha as a whole could be expected to be favourably disposed towards OR/MS. The very high rating of the General Manager who has acted as the sponsor of OR/MS since its first introduction to Alpha demonstrates the importance of effective sponsorship at all stages during the Life Cycle.

EVALUATION OF FACTORS INFLUENCING TOP MANAGEMENT RECEPTIVITY TOWARDS OR/MS

Several factors are thought to influence the Receptivity of Top Management towards OR/MS. These factors are classified either as Controlling, or Assisting depending upon the influence they exert on Receptivity. The Rating procedure for the determination of the extent to which the various factors are present or absent is described in detail in Chapter 8. The rating of Company Alpha is shown below.

CONTROLLING	Score
- Influence of International Parent Company/ Associates	M
- Professionally Trained Top Managers	P
- Availability of EDP Expertise in OR/MS	P

ASSISTING	
- Top Management Exposure to Innovation	M
- Influence of Management Graduates	P
- Influence of International Consultants	M
- Use of OR/MS by Competition	N
- Increased Competition, Reduced Profits etc.	M
- Increased Size of Operation	M
- Government Involvement	N

EVALUATION OF FACTORS INFLUENCING OR/MS SUCCESS

The previous section in this Appendix indicated that Company Alpha had achieved a reasonable level of Success in all projects attempted. Apart from the Long Range Planning project which was still relatively new, the three projects that had been completed at the time of the field studies were rated at levels of "Success" and "Success +", whilst the Financial Forecasting project achieved a "Moderate Success" rating.

There are a number of factors which are believed to be associated with Success. These factors are identified either as Controlling or Assisting depending upon their influence in the determination of Success. The scoring of the various factors is shown below.

CONTROLLING	Score
- Level of Top Management Support	P
- Level and Nature of Sponsorship	P
- Level of Systems Development	M
- Availability of Computer Support	P
ASSISTING	
- Influence and Reputation of OR/MS group	M
- Relevance and Success of Projects	P
- Formalization of Procedures	M
- Level of Client Receptivity	M
- Nature and Competence of OR/MS Personnel	P

EVALUATION OF THE DEVELOPMENT OF OR/MS ACTIVITY IN COMPANY ALPHA

The introduction and development of Management Science activity in Company Alpha has been singularly successful. There is considerable support for the Management Services group and the group has carried out successful work. Although current projects are not progressing as well as had been anticipated, the status and stability of the MS group should be sufficient to achieve desired objectives.

The MS group at Company Alpha came into being as a result of an Internal Evolutionary Process as well as an Externally Induced Process. The present General Manager was responsible for the start of both procedures.

In an Internally Induced Process more and more use is made of OR techniques until there is enough support to create a formal OR/MS activity. The Planning Team which was responsible for

CPM/PERT projects within Alpha became part of the MS group when it was created. However by the time this happened the Planning Team had firmly established the success of CPM/PERT.

The General Manager, who had previously been responsible for the introduction of PERT/CPM and the creation of the Planning Team, then started the Inventory Project using outside consultants and two analysts. At the same time he recruited as his Personal Assistant, an executive with experience in engineering as well as Management Science. The consultants, the analysts, the General Manager and his Assistant constituted a powerful team which virtually ensured the success of the Inventory Project. By the end of 1971 there were two accepted OR applications within Alpha, and the formal establishment of the MS group completed the recognised cycle of the Internal Evolutionary Process.

However the Externally Induced Process of the introduction of a MS group postulates that a person with power and influence within the organization recognises potential areas of application for OR/MS. As a result of his influence a formal group is established generally with a substantial initial charter. The General Manager emerges as a very powerful sponsor of OR/MS in Company Alpha and even though it took five years from the introduction of CPM/PERT to the creation of the MS group the cycle corresponds to an Externally Induced Process with a time lag.

The OR/MS Sponsor

The General Manager has played a critical part in the introduction of OR/MS. In 1966 as Manager of the Projects Division he had achieved high status as an intelligent engineer with an outstanding record. This was sufficient to enable him to act as a powerful change agent when he introduced the concept of CPM/PERT. The obvious benefits of formal planning in Company Alpha contributed to his promotion to General Manager in 1967. By this time his record as an innovator was instrumental in getting the Managing Director to approve the purchase of a computer, the computerization of the accounting and financial systems, and the start of the Inventory Control project. To do this the General Manager recruited two personal friends of his own age to supply expertise which he did not have - the DP and MS managers - as well as two additional analysts. By 1971 when the MS group was formally created the status of both the General Manager and the members of the MS group were sufficiently high to ensure top management support. The only opposition came from the Manager of Administration and Finance who bitterly resented the intrusion of the General Manager into his sphere of activity. This opposition was partially overcome by allocating the DP department to the MAF, and thereby restoring the responsibility for development of information systems to the MAF. By this time most of the development work had been done and the systems were successfully installed.

The aspirations and background of the General Manager meet most of the criteria which are normally associated with Sponsorship. He had formal exposure to OR/MS technology and was orientated towards innovation. He had established himself securely in an organization where the technology favoured the development of OR/MS. The organization was sufficiently small to ensure that the General Manager could personally direct the implementation of OR/MS projects thereby ensuring their success and as a result enhancing his status in the eyes of the organization and the Managing Director. The history of the development of MS at Alpha shows that the success of the General Manager resulted from the success of the MS group and vice versa.

It was only after the group was formally established and the success of the General Manager was guaranteed that projects such as Financial Planning and Long Range Planning were introduced. The outcome of these projects was not as certain as the CPM/PERT and Inventory exercises but by this time the status of both the General Manager and the group was sufficiently high to run the risk of possible failure.

The Life Cycle of the MS Group in Company Alpha

The history of OR/MS activities in the Company between 1966 and 1973 offer a useful means of comparison with the concept of the Life Cycle of OR/MS groups.

Prebirth and Introductory Phases:

There appear to have been two portions of the Introductory phase:

1966-1967: The start of the CPM/PERT projects in the Projects and Construction Division. The allocation of the two analysts to develop applications within the two Divisions.

1968-1970: The start of the Inventory Control projects. The allocation of resources to engage consultants to work on the project.

In both instances, although the time span differs, Management was evaluating the specific OR/MS techniques being employed and had not committed itself to permanent establishment of either activities. The hiring of the General Manager's personal assistant in 1968 cannot be considered as a permanent allocation to OR/MS activities as this executive was involved in the computerization exercise.

Transitional Phase:

Here there are two portions of the Transitional phase in which Management has indicated the intention of using OR/MS in the decision-making processes of the organization. Although OR/MS is not a permanent organizational activity there is no time limit on its charter.

1967-1971: The creation of the Planning Team which drew on two engineers from the Construction and Projects Division.

The team had no formal organizational location but its existence was secure as all projects had to be submitted to it for approval.

1970-1971: The allocation of two analysts to the Inventory Control project to work with the consultants. At this stage Management had committed itself to the Inventory project although the function of the analysts had not been defined in the organizational structure.

Maturity Phase:

At this stage Management has accepted the OR/MS function as a permanent part of the organization. OR/MS is accepted as an essential part of the decision making process and funds are allocated accordingly.

1971 onwards: The creation of the MS group, the appointment of the Manager and four analysts.

It is clear that by 1973 the MS group had reached the Maturity stage in the Life Cycle. This belief is reinforced by the fact that the original sponsor - the General Manager - is now attempting to disengage himself from the group and make it subject to the normal procedural requirements that apply within Company Alpha. The progress through the Life Cycle has been assisted by the sponsorship of the General Manager, and as the General Manager is apparently destined to fill the position of Managing Director the life of the MS group seems assured.

The Primary Diffusion Process was completed in 1966 when the CPM/PERT projects were started. The Secondary Process was complete in 1973 when the MS group was firmly established in Company Alpha.

B I B L I O G R A P H Y

Ackoff, R.L.; and Rivett, P. A Manager's Guide to Operations Research. New York: John Wiley and Sons, 1963

Ackoff, R.L.; and Sasieni, M.W. Fundamentals of Operations Research. New York: John Wiley and Sons, 1968

Argyris, C. "Management Information Systems." Management Science, February 1971

Bean, A.S. "Some Considerations on the Management of Management Science Groups." Paper presented at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969

Beer, S. "Cybernetics and Operations Research." Operational Research Quarterly, March 1959

Beer, S. Decision and Control. New York: John Wiley and Sons, 1966

Benikos, E.S.; et al. "Use of Operations Research in South African Commerce and Industry." Unpublished MBA Group Project. Graduate School of Business, University of Cape Town, Cape Town, December, 1970

Berners-Lee, C.M., ed. Models for Decision. London: English Universities Press, 1965

Bird, C.; Dew, J.; et al. "Evaluation of a Computer System at Company X." Unpublished Student Project. Graduate School of Business, University of Cape Town, July 1972

Blumenthal, S.C. Management Information Systems, A Framework for Planning and Development. Englewood Cliffs, New Jersey: Prentice Hall, 1969

Boulding, K.E. "General Systems Theory - The Skeleton of Science." Management Science, April 1956

Burnett, P.D.; and Kassarjian, H.H. Consumer Behaviour. Englewood Cliffs, New Jersey: Prentice Hall Inc., 1972

Butler, G.J.; Bisset, M.J.; et al. "Applications of Operations Research." Unpublished Student Project. Graduate School of Business, University of Cape Town, July 1974

Caywood, T.E. "How Can We Improve Operations Research." Journal of the Operations Research Society of America, October 1971

Churchman, G.L.; Ackoff, R.L.; and Ackoff, E.L. Introduction to Operations Research. New York: John Wiley and Sons, 1957

----- "Computers, Who's Got What." Management Magazine, December 1973

Couger, W. Address by Mr. Couger of Burroughs Computers to Students at the Graduate School of Business, November 1974

Crowther, J.G.; and Whiddington, R. Science at War. London: H.M. Stationery Office, 1948. Cited by P.M. Morse and G.E. Kimball. Methods of Operations Research. Cambridge, Mass: The MIT Press

----- "Declassified Information." Management Magazine, April 1973

Dearden, J.; and Mote, V.L. "Operations Research at the Cross-roads." European Business, October 1968

Engel, J.H. "Operations Research for the U.S. Navy Service World War II." Journal of the Operations Research Society of America, November-December 1960

Erlang, A.K. "Solution of some problems in the theory of probabilities of significance in Automatic Telephone Exchanges." The Post Office Electrical Engineers Journal, Vol. 10, 1917-18. Cited by L. Takács. Introduction to the Theory of Queues. New York: Oxford University Press, 1962

Fayol, H. General and Industrial Management. Translated by C. Stores. London: Pitman, 1963

Feldberg, M. Organizational Behaviour: Text and Cases. Cape Town: Juta and Co., 1975

Feldberg, M. "Summary of the Place of the Management Sciences in South Africa." Paper delivered to the Fifth Meeting of the International Federation of Operations Research Societies, Venice, Italy, June 1969

Gilbreth, F.B.; and Gilbreth, L.E. Applied Motion Study. New York: The MacMillan Company, 1917

Grant, C.V. "Management Scientists as Change Agents." Systems/Stelsels, November/December 1972

Grindley, K.; and Humble, J. The Effective Computer. London: McGraw-Hill, 1973

Head, R.V. "Management Information Systems, A Critical Appraisal." Datamation, May 1967

Hertz, D.B. "Has Management Science Reached a Dead End?" Innovation, No. 25 (1971)

Hertz, D.B. New Power for Management. New York: McGraw-Hill, 1969

Hough, J.; Betts, R.J.; and Eilon, S. "Career Patters of Operational Research Workers in the U.K." Paper delivered at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969

Karg, R.L.; and Thomson, G.L. "A Heuristic Approach to Solving the Travelling Salesman Problem." Management Science, January 1964

Kast, F.E.; and Rosenzweig, J.E. Organization and Management - A Systems Approach. New York: McGraw-Hill, 1970

Kawase, T. "Perspective on Management Sciences in Japan." Paper delivered at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969

Khoury, E.H.; and Nelson, H.W. "Simulation in Financial Planning." Management Services, March-April 1965

King, C.W. "Fashion Adoption: A Rebuttal to the 'Trickle Down Theory'." Dimensions of Consumer Behaviour. Edited by J.U. McNeal. New York: Appleton-Century Crofts, 1969. Citing Dr. E. Robinson. "The Economics of Fashion Demand." The Quarterly Journal of Economics, Vol. 75 No. 3 (1961) and G. Simmel. "Fashion." The International Quarterly, Vol. X (October 1904)

Kotler, P. "Operations Research in Marketing." Harvard Business Review, January/February 1967

Kuehn, A.A.; and Hamburger, M.J. "A Heuristic Program for Locating Warehouses." Management Science, July 1963

Lanchester, F.W. Aircraft in Warfare, Dawn of the Fourth Arm. London: Constable and Company, 1916. Cited by P.M. Morse and G.E. Kimball. Methods of Operations Research. Cambridge, Mass: The MIT Press

Levinson, H.C. "Experiences in Commercial Operations Research." Journal of the Operations Research Society of America, I, 1953

Malcolm, D.G. "On the Need for Improvement in Implementation of OR." Management Science, February 1965

Mance, R., (ed). The Arts of Management. London: McGraw-Hill, 1970

Masterson, D.D. Presidential Address to the Operations Research Society of South Africa, Annual Conference, 1972

McClelland, D.C. "Business Drive and National Achievement." Harvard Business Review, July/August 1962

McCleskey, J.F.; and Trefethen, F.N. Operations Research for Management. Baltimore: The John Hopkins Press, 1954

McNeal, J.U. An Introduction to Consumer Behaviour. New York: John Wiley & Sons Inc., 1973

Meyer, H.E. "The Fortune Directory of the 300 Largest Industrial Corporation Outside the US." Fortune, August 1974

Miller, D.W.; and Starr, M.K. Executive Decisions and Operations Research. Englewood Cliffs, New Jersey: Prentice Hall, 1960

Moore, C.M.; Hughes, J.P.; et al. "The Scope of Educational Opportunities in Operations Research in South Africa." Unpublished Student Project, Graduate School of Business, University of Cape Town, Cape Town, July 1974

Morse, P.M.; and Kimball, G.E. Methods of Operations Research. Massachusetts Institute of Technology: The Technology Press. New York: John Wiley and Sons, 1951

Naylor, T.H.; Balintfy, J.L.; and Bundick, D.S. Computer Simulation Techniques. New York: John Wiley and Sons, 1966

Neal, R.D.; and Radnor, M. "The Relation Between Formal Procedures for Pursuing OR/MS Activities and OR/MS Group Success." Journal of the Operations Research Society of America, March/April 1973

Northwestern University, Washington Operations Research Council, American Society of Public Administration. "Workshop on Management Science in the Federal Civilian Government." Fredericksburg, Virginia, December 8-11, 1968. Cited by D.A. Tansik. "Several Hypothesised Influences of Organizational Goal Structures." Paper delivered at the XVI International Meeting of the Institute of Management Sciences, New York City, March 1969

Pettigrew, A. "Intergroup Conflict and Role Strain." Journal of Management Studies, May 1968

Prince, T.R. Information Systems for Planning and Control. Homewood, Illinois: Richard D. Irwin, 1966

Radnor, M.; and Bean, A.S. "Top Management Support for Management Science." Omega, Vol. 2 No. 1 (1974)

Radnor, M.; and Neal, R.D. "The Progress of Management Science Activities in Large US Industrial Corporations." Journal of the Operations Research Society of America, March/April 1973

Radnor, M.; Rubenstein, A.H.; and Bean, A.S. "Integration and Utilization of Management Science Activities in Organizations." Operations Research Quarterly, June 1968

Radnor, M.; Rubenstein, A.H.; and Tansik, D.A. "Implementation in Operations Research and R and D: In Government and Business Organizations." Paper presented at the 34th National Meeting of the Operations Research Society of America, Philadelphia, Pa., November 6, 1968

Riggs, J.L. Production Systems. New York: John Wiley and Sons, 1970

Rogers, E.M. Diffusion of Innovation. New York: The Free Press, 1962

Rogers, E.M.; and Shoemaker, F.F. Communication of Innovations: A Cross-Cultural Approach. New York: The Free Press, 1971

Rubenstein, A.H. "Integration of Operations Research in the Firm." The Journal of Industrial Engineering. Vol. XI, No. 5 (1960)

Rubenstein, A.H.; Radnor, M.; Baker, M.F.; et al. "Some Organizational Factors Related to the Effectiveness of Management Science Groups in Industry." Management Science, April 1967

Rudolph, G.J. Presidential Address to the South African Operations Research Society, 22-23 November 1973

Schem, E.A. Process Consultation: Its Role in Organization Development. Reading, Mass: Addison-Wesley, 1969. Cited by C.V. Grant. "Management Scientists as Change Agents." Systems/Stelsels, November/December 1972

Schultz, Randall L.; and Slevin, Dennis P. Implementing Operations Research/Management Science. New York: American Elsevier Publishing Company, Inc., 1975

Scott, L.G. Organization Theory. Homewood, Illinois: Richard D. Irwin, 1957. Cited by C.V. Grant. "Management Scientists as Change Agents." Systems/Stelsels, November/December 1972

Simon, H.A. The New Science of Management Decisions. New York: Harper and Row Inc., 1960

Spicer, E.H., (ed.). Human Problems in Technological Change. New York: John Wiley and Sons Inc., 1965

Taylor, F.W. Scientific Management. New York: Harper Press, 1947

Thierauf, R.J.; and Grosse, R.A. Decision-Making Through Operations Research. New York: John Wiley and Sons, 1970

Tocher, K.D. "The Dilemmas of Operational Research." Operations Research Quarterly, June 1972

----- "Top Companies." Financial Mail Special Survey, May 24, 1974

Turban, E. "A Sample Survey of Operations Research Activities at Corporate Level." Journal of the Operations Research Society of America, May/June 1972

Watson-Watt, Sir R. Three Steps to Victory. London: Odhams Press, 1959

Wagner, H.M. "The A.B.C.'s of OR." Journal of the Operations Research Society of America, October 1971

----- "What Long Range Planning Has Done (And Not Done) for the Top 100 Companies." Management Magazine, May 1974

Wiest, J.D. "Heuristic Programming for Decision-Making." Harvard Business Review, September/October, 1966

Wright, D.S. "Survey of Five South African Computer Manufacturers." Unpublished Research Paper, Graduate School of Business, University of Cape Town, Cape Town, December 1974

Personal communication with Mr. M. Morris, Managing Director, ASAP Computer Bureau, December 1973

Data obtained from personal communication with the Secretaries of:
Operations Research Society (UK), 28th November 1974
Institute of Management Science (USA), 23rd September 1974

Personal communication from the Secretary of the Operations Research Society of South Africa, 9th August 1974

Personel communication with the President of the S.A. Computer Society, 4th July 1974

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